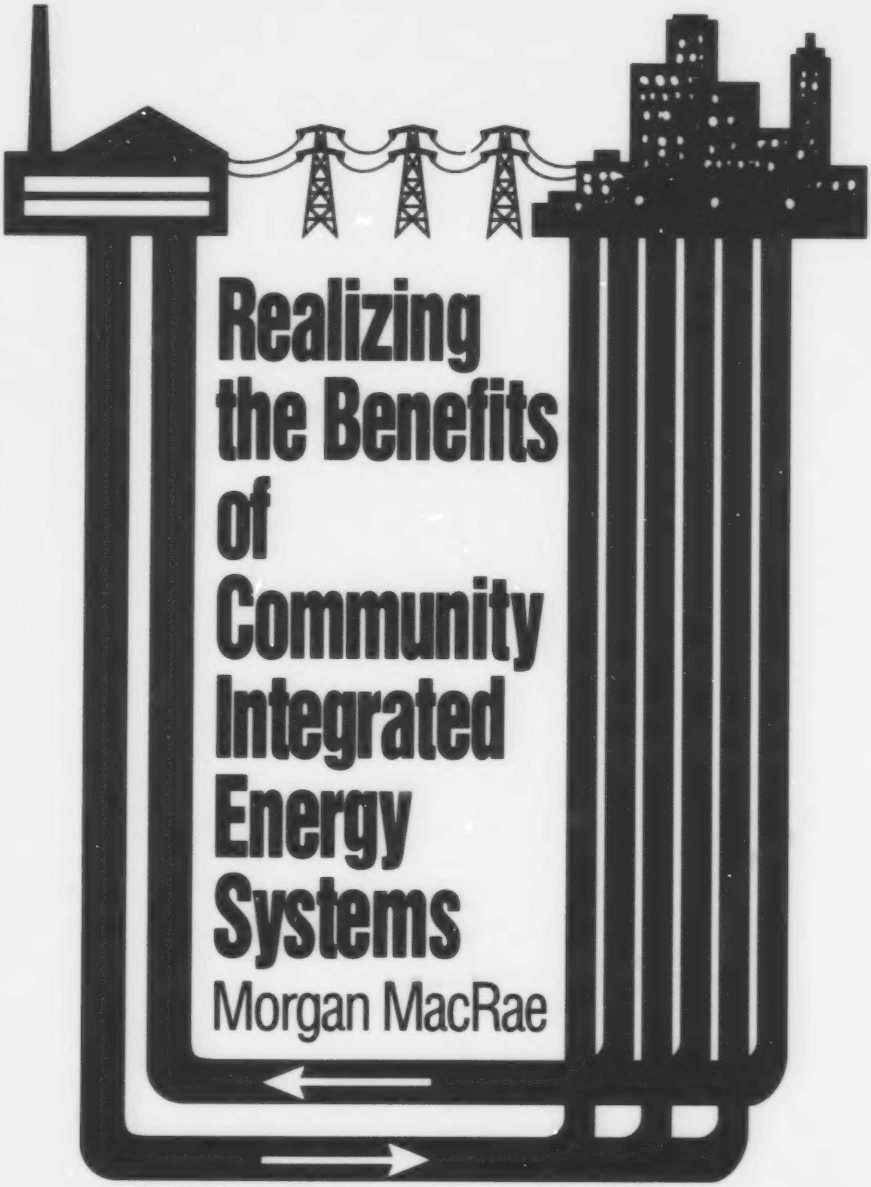

Realizing the Benefits of Community Integrated Energy Systems

Morgan MacRae

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CANADIAN ENERGY RESEARCH INSTITUTE

REALIZING THE BENEFITS OF COMMUNITY INTEGRATED ENERGY SYSTEMS

MORGAN MacRAE

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Realizing the Benefits of
Community Integrated Energy Systems

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PREFACE

The author wishes to express his sincere appreciation to the Advisory Committee members for their thoughtful and constructive comments on this study. The Canadian Energy Research Institute also gratefully acknowledges the technical and financial assistance of the Canada Centre for Mineral and Energy Technology (CANMET) in undertaking this research.

Special thanks are due to a number of CERI staff. Tony Reinsch for his guidance and editorial advice. Beverly Kovacs typed numerous editorial revisions and helped put the finishing touches to the study. Megan Murphy created the graphics. Wendy Faid and Lynn Storey of the I.N. McKinnon Memorial Library assisted greatly in numerous requests for journal articles and books. Dr. Gerry Angevine provided editorial comments.

FOREWORD

District energy--the distribution of heat via underground pipes to two or more customers--is a very old technology which has been given new life by the energy crises of the seventies, the garbage crises of the eighties, and the economic and environmental crises faced by many urban areas today. It is a technology which can reduce dependence upon fossil fuel energy supplies while providing answers to questions related to garbage disposal, revitalization of urban areas, and environmental degradation.[1]

During ancient Roman times, warm water was circulated through open trenches to provide heating for buildings and baths in Pompeii, and in Britain, the Roman Legionaires used geothermal heat to provide heating for baths and buildings. In many places you can still see how heated water was circulated from home to home through a network of trenches that went through the cellars of the buildings. Hundreds of years later, in Chaudes-Aigues Cantal in France, warm water was distributed through wooden pipes that are still used today.

In 1877, Birdsill Holly established the first commercial district heating system in the U.S. in Lockport, New York. He used a boiler in his cellar as the central heat source and built a loop consisting of steam pipes, radiators, and condensate return lines.

In Denmark, the first district heating system was established in Frederiksberg (a suburb of Copenhagen) in 1891. The heat was provided by an electrical generating plant and supplied a hospital and several government buildings.

In 1893, the Municipal Council Building in Hamburg, Germany, was receiving heat from a central power station and in 1900, in order to minimize risk of fire damage to valuable art treasures, government buildings in Dresden, Germany, were linked to a central heating system.[2]

---

[1] Gordon R. Bloomquist, John T. Nimmons, and Kevin Rafferty, *District Heating Development Guide, Legal, Institutional, and Marketing Issues, Volume I* (Olympia, Washington: Washington State Energy Office, October 1988), p. ix.

[2] Ibid., p. 2.

Throughout the first half of this century, district heating prospered in the U.S. and to a lesser extent in Scandinavia and Europe.

However, following the Second World War, the U.S., Europe, and Scandinavia went in completely different directions. In the U.S., rapid urban growth as well as economies of scale forced most major electricity generating plants to locate outside urban areas. The cost of building central heating plants solely to supply district energy[3] was prohibitively expensive and an abundance of inexpensive electricity, oil, and natural gas spelled doom for many district heating companies.

In Europe and Scandinavia, without the abundance of electricity and natural gas that was available in the U.S., district energy prospered as more and more combined heat and power plants were built to supply an ever increasing demand for electricity. By the mid 1960s, most large- and medium-sized towns in Denmark were served by district heating systems, providing nearly 50 percent of the total heat consumption. In Sweden, where district heating began only 40 years ago, over 40 percent of the country's heat is provided by district energy systems. The situation in Finland and Germany is very similar, as is the case throughout much of northern Europe.

The 1970s brought another round of changes to district heating in the U.S., Scandinavia and Europe. The oil shortages of the early and late 1970s prompted countries such as Sweden and Denmark, which depended upon imported oil for nearly 90 percent of their district heating, to look at alternatives such as garbage incineration, waste heat, and renewable resources. The oil crises of the 1970s also caused a renewal of interest in district heating in the U.S. With help from the U.S. Department of Housing and Development (HUD) and U.S. Department of Energy (DOE), oil-fired district heating systems began to be refurbished and local governments across the U.S. began to investigate if and how district energy could benefit their communities.[4]

District energy is a technology that, if it is to be fully developed, must overcome various regulatory, financing, and market entry barriers. District energy systems are capital intensive, making financing and initial market penetration extremely difficult. Overcoming these barriers is often made more difficult by federal, provincial and municipal regulatory policy.

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[3] Today's technology permits heat to be used to generate cooling. District energy is an all inclusive term that refers to heating, cooling or a system that provides both heating and cooling.

[4] Gordon R. Bloomquist, John T. Nimmons, and Kevin Rafferty, *District Heating Development Guide, Legal, Institutional, and Marketing Issues, Volume I*, p. 3.

Many different organizations--municipal governments, utilities, owners and managers of large buildings, and private developers--are affected by district energy systems. Each of these organizations has its own mandate, interests and method for making commitments for capital investments. Each also has its perceptions and, in many cases, misperceptions of district heating and cooling systems. A major challenge exists, therefore, for district energy proponent(s) to gain acceptance and support from this diverse set of organizations.[5]

Gaining support for a district energy system requires the effective promotion of the advantages and benefits of the community integrated energy systems (CIES) approach in general, and the proposed project in particular.

The need which has been identified, therefore, is to provide practical assistance to those people who are attempting to solicit support for a new, expanded or modernized district energy system. The purpose of this study is to help policy-makers and the general public to better understand the benefits of district energy and how to best implement new district energy projects across Canada.

Because many technical issues have been covered in detail in the literature, Part One of this CERI study provides only a brief summary of the most important technical considerations that a district energy feasibility or design study must evaluate. This study concentrates instead on planning, financing, marketing and regulatory changes that are needed to support accelerated district energy development in Canadian communities.

Part Two of this study provides the reader with examples of how district energy has developed in northern Europe and also reviews its development in Charlottetown, Toronto and Edmonton.

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[5] International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *District Energy Systems, Promotional Manual for System Developers and Operators*, Second Draft, November 1991.

EXECUTIVE SUMMARY

Introduction

Increasing world-wide attention is being given to ways to improve energy efficiency because of the environmental impacts of acid rain, global warming and ozone depletion. A key factor hindering the more efficient use of energy in Canada has been the **fractionalization of responsibility** for providing the various components of the energy using system. Builders provide the energy using equipment, natural gas companies provide the gas, and building owners buy the gas. Each actor has his own interests.

An exciting means of contributing to greater energy efficiency is district energy or community integrated energy systems (CIES). CIES distribute thermal energy, in the form of chilled water, hot water or steam, from a central plant or network of plants to individual buildings to provide space heating, air conditioning, domestic hot water and industrial process energy via underground pipes.

Modern district energy technology based on hot water has been standard technology in Europe for many years, in applications equally as challenging as those faced in Canada. In fact, the combination of cold winter temperatures and high cooling requirements offers Canada even better potential for CIES development in Canada than Europe, where district energy is currently used only for space heating. In Canada, the potential for central cooling as an alternative to on-site CFC chillers is a major opportunity for district energy, as the federal government has committed Canada to phasing out production of CFC's by 1995.

District energy has been given new life by the energy crises of the 1970s, the garbage crises of the 1980s and the economic-environmental crises of the 1990s. It is a technology that can reduce dependence upon fossil fuels while providing answers to questions related to garbage disposal, revitalization of urban areas, and environmental degradation.

District energy is a straightforward, commercially proven technology that has been used for decades in many parts of Europe. **While research is being done to improve the efficiency and cost**

effectiveness of district energy technology, it is already feasible for many situations in Canada. Technology is already available to enable energy for space and process heating and cooling to be supplied from sources as diverse as waste heat from electric generating stations, waste-to-energy plants, and heat pumps using sewage water.

The rapidly inflating energy prices of the 1970s focussed attention on achieving an improved balance between energy supplies and demands. The environmental challenges of the 1990s are calling for similar broad-based strategies that will achieve greater energy efficiency and reduce environmental impacts, while at the same time ensuring that these actions do not place Canada at a competitive disadvantage relative to its trading partners.

This study concentrates on planning, financing, marketing and regulatory changes that are needed to support accelerated district energy development in Canadian communities. The purpose of the study is to help policy-makers and the general public appreciate the benefits of, and how best to overcome existing barriers to, CIES development across Canada.

Specifically, this study's objectives are:

- to examine the key concepts underlying community integrated energy systems;
- to identify the benefits of district energy, including its use as a strategy to reduce greenhouse gas (GHG) emissions in Canada;
- to identify the current barriers to CIES in Canada;
- to propose various strategies to overcome these barriers and thereby promote greater use of CIES across Canada; and
- to stress the importance of analysing energy-environment-economy issues simultaneously rather than separately.

This study is not intended to provide a quantitative assessment of the potential for district energy in Canada, nor is it meant to provide a detailed technical and economic analysis of specific projects. Detailed site-specific costs and energy use data are required for such an undertaking.

Reference is made throughout the study to various regulatory bodies and to the energy situation in Ontario. Where the reference is to Ontario, industry and government decision-makers in other jurisdictions across Canada can infer how the various issues and recommendations relate to them. For example, instead of recommending in a generic vein that "regulatory boards should do this or that", specific reference is made to the Ontario Energy Board and the Environmental Assessment Review Board. But, regulators in Alberta can, for example, read these as the Alberta Public Utilities Board and the Alberta Energy Resources Conservation Board, respectively.

The study's audience includes industry and government decision-makers at the federal, provincial and municipal levels, gas and electric utilities, producers and distributors, regulatory agencies, building owners, the investment community, engineering and architectural consultants and all Canadians concerned with energy-environment-economy linkages.

Realizing the Benefits

If they act on the recommendations presented in this study, Canadians stand to benefit significantly. **District energy fits very well with the major interests of governments in the areas of energy, the environment and the economy:**

- Most governments provide active support for the policy goals of energy efficiency, diversification of energy supplies and the use of local energy sources; district energy systems contribute to the achievement of **all** three of these goals.

- The environmental benefits of CIES address concerns at the provincial and national, as well as municipal and international levels. CIES facilitate the reduction, dispersion and control of air pollution levels, thereby ameliorating both local and long-range air pollution concerns. Incineration and other treatments of waste streams can also provide positive net environmental impacts to the community and region.

- All governments support the goals of economic efficiency and productivity improvements that can be realized through technically-sound capital investments. These goals represent the underlying basis for the economic viability of community integrated energy systems.

Among the environmental benefits of CIES are the following:

(i) Greater efficiency in fuel use reduces the amount of CO_2 emitted, thereby reducing the community's impact on global warming. The efficiency of central boilers is in the 80-85 percent range, compared to 50-60 percent for decentralized boilers.

(ii) Single point emissions are much easier to control and monitor with state-of-the-art pollution control equipment.

(iii) Where municipal solid waste can be incinerated, the use of available waste streams as an energy source (rather than landfill) provides for the displacement of conventional fuels thereby reducing carbon dioxide (CO_2) and methane (CH_4) emissions. It can also reduce landfill requirements by up to 90 percent.

Community integrated energy systems offer a wide variety of benefits cutting across the entire spectrum of energy users in Canada.

For Society, CIES offers:

- flexibility in selection of heat source
- reduced dependence on a single heat source
- better utilization of fuel
- more efficient operation
- reduced emissions through more effective use of flue-gas scrubbing and cleaning technologies
- district energy cooling can be made readily available using ammonia and heat-based technologies to facilitate the elimination of CFC use
- improved energy efficiency that reduces all emissions, resulting in less global and local pollution.

For Communities, CIES offers:

- improved community energy management and utilization
- a major role for communities in controlling environmental emissions
- greater potential for communities to utilize local energy resources
- energy dollars reinvested in the local economy
- benefits from improved economy and energy-efficiency.

For Building Owners and Tenants, CIES offers:

- lower heating costs
- simpler, safer and cheaper operation
- more space for other purposes
- greater comfort
- increased reliability.

To realize the benefits of CIES, interest and involvement will have to be developed within the utility sector, a sector well-situated to meet the financial and technical challenges of district energy systems development. CIES can avoid many of the perceived disadvantages of continued large power plant development by improving the efficiency of existing electric power stations by integrating combined heat and electric power facilities with CIES, and broadening the planning for new facilities to meet electrical and heating demands via community integrated resource planning (IRP). Other potential benefits to utility operations include:

- CO_2 emissions from the production of electricity can be substantially reduced at low technology risk
- electrical energy can be stored in the form of usable thermal energy
- electrical peak load demand can be substantially reduced as waste heat can be used for space heat or cooling and, thereby, displace electricity production; and
- better load control where utilities use cogenerated power to lower their peak demand.

District energy technology could also be instrumental in realizing the use of indigenous resources and furthering the commercial development of clean coal technologies such as Integrated Gasification Combined Cycle and Pressurized Fluidized Bed Combustion. The application of these technologies could be of considerable assistance in furthering Canadian development and would help support the sale of Canadian technology to countries that are in dire need of cost-effective solutions to mounting environmental problems.

Community integrated energy systems can supplant natural gas and oil-fired space heating in high- and medium-density commercial, institutional and industrial load areas. This replacement can assist in making Canadian natural gas and oil reserves available for longer periods of time and/or increase the volumes available for export.

District energy represents an investment in a city's infrastructure that uses initial capital investment to achieve long-term cost savings from a reduction in the amounts of energy used. The ability to use several fuels can be engineered to enable each system to take advantage of local energy sources, such as municipal waste, sewage sludge and other fuels often available in the community. Regional air quality will also improve because emissions can be more closely controlled at a central heat source than at the many, smaller smoke stacks spread across the community.

Construction of a CIES provides employment opportunities for skilled and unskilled workers for several years. Operation and maintenance of the system provide employment for others, while the availability of reasonably priced, stable thermal services means growth and business expansion that provides still more spin-off employment opportunities. By helping to create jobs and providing energy-wise incentives to locate downtown, district energy spurs economic development and downtown revitalization.

The local community benefits when local resources are used because energy dollars are recycled in the local economy. For example, *The PEI Energy Corporation* uses locally available wood chips as fuel for its district energy heating system. Previously, about 90 percent of the city's energy dollars went outside the province, but now with locally available woodchips, only 25 percent of the energy requirements are being purchased outside the province.

Barriers to District Energy

The principal barriers to greater Canadian CIES development include siting criteria for power plants; the traditional attitudes of most gas and electric utilities with respect to the combined production of heat and power (CHP); environmental rules that fail to recognize the value of increased energy efficiency; finance and investment; jurisdiction; rate and tariff structure; and public and investment community attitudes.

The resolution of these issues will involve a complex balancing of competing priorities that can only be achieved through coordinated action among the involved parties. While **most** of these issues can be resolved at the municipal level, several require solutions at the federal and provincial government levels.

(1) Commitment, Policy and Initiatives

Community integrated energy systems are a classic example of an energy efficient technology that is not properly recognized by existing market forces. The societal and environmental benefits of CIES are sufficient to warrant extraordinary steps to overcome existing barriers to this technology's development.

Visible direction and encouragement by government is vital to ensure that Canadians use energy more efficiently. **Today's regulations are simply not designed to promote energy efficiency and minimize environmental problems**.

Government commitment to use district energy can be viewed from two perspectives. First, district energy lowers costs for heating and cooling when all costs, including capital, labour, maintenance, supplies as well as fuel, electricity and environmental impacts are accounted for. Second, federal, provincial and municipal governments are owners of, and tenants in, massive amounts of commercial office space in the downtown core areas of Canadian cities. For example, the federal government owns or leases 25 million square metres of office space. Canada's provincial, regional and municipal governments own or lease many more millions of square metres of office space, most of it located in Canadian downtown cores. Many of these facilities could be used to help reach the critical baseloads necessary for commercial application of CIES technology.

An equally important reason for government support is that government utilization of new technologies would lead to rapid advances in those technologies, resulting in accelerated market introduction and enhanced overall economic gains for Canada. Export of Canadian district energy expertise and services would also be enhanced.

In Europe, CIES are supported by clear policy positions and various forms of legislation and public subsidies. Many European countries have translated policies of support for CIES into commitments by connecting government-owned buildings and utilities to CIES. **In many of these countries, electric utilities cannot build additional electrical generating plants unless these plants are combined heat and power facilities that are tied into a community integrated energy network.** A discussion of government support for CIES and district energy development is provided in Chapter 5 and Part II of the study.

Recommendations

(i) A policy of connecting government-owned facilities on a long-term contractual basis to a CIES network and favoring the leasing of commercial office space from buildings connected to CIES would greatly assist district energy projects with the initial baseload necessary to make CIES economically and financially attractive across Canada.

(ii) To ensure that CIES is used to address important Canadian energy-environment-economy issues, coherent strategies must be developed to overcome institutional barriers such as existing legislation, regulations, standards, practices and attitudes. Coherent marketing programs together with financial incentives are also needed.

(iii) Government and industry should initiate:

- installation of CHP systems in planned power stations and the conversion of existing stations;
- development of improved power siting criteria to favor locations closer to heating, cooling and process loads such as urban and industrial centers;
- improved awareness of the feasibility of transporting hot water over long distances;
- identification of existing heating loads and encouragement of the retrofitting of power stations, where possible;
- equitable pricing systems and negotiating procedures for the purchase of electricity from cogeneration facilities;
- consideration of waste heat recovery from industry, waste incineration or other low grade fuel or heat sources; and
- a call for more efficient use of the energy available in our fuel resources through more efficient methods of converting that energy to a useable form.

(iv) Government and industry should take steps to encourage:

- use of comprehensive integrated resource planning (IRP) by communities;

- the incorporation of CHP systems as essential elements of energy and environmental planning;
- identification and resolution of legal and financial constraints;
- the coordination of assessments to compare the direct economic and environmental benefits of CHP systems to the real costs of individual energy production and required environmental controls; and
- community energy education programs to elevate the awareness of district heating and cooling systems are undertaken and implemented among business and government leaders, educational institutions, environmental actions groups and others.

(v) Government and industry should take steps to:

- establish awareness of and credibility for the social and economic benefits which can be realized by increased use of district energy systems;
- establish an understanding of how the technical, economic and environmental feasibility assessments of proposed district energy system projects should be conducted;
- identify specific district energy technology opportunities that require demonstration support;
- identify regulatory barriers that are impeding the acceptance of district energy systems;
- establish awareness of and credibility for the range of technical options that are available or are at the demonstration stage for improving operating performance, optimizing system capabilities and adapting to new factors, such as environmental concerns and utility buyback policies;
- provide guidance as to how both preliminary and detailed feasibility assessments should be undertaken for the technical options that may be used for their systems;

(vi) Government should assess various programs suggested to support accelerated community integrated energy system development, including:

- provision of loan guarantees;
- prohibiting new point source pollutants for heat or energy generation unless energy-from-waste systems are included;
- granting zoning requests for downtown waste processing facilities;
- issuing specific guidelines defining public regulatory jurisdiction over waste-to-energy district heating systems;
- where feasible, encouraging government energy/heat consumers to enter into long-term contracts with district energy systems; and
- revising regulatory review processes for a one-window approach (i.e., joint hearings of Ontario's Environmental Assessment Board and the Ontario Energy Board) which credit the reduction in emissions from district energy systems.

(2) Risk Sharing and Financial Incentives

As industries tend to invest to increase production in preference to projects aimed at conserving energy, government should consider incentives that will accelerate the adoption of technologies and processes that are in the national interest.

Recommendations

(i) High capital costs, a need for well-trained design, operation and maintenance personnel as well as jurisdictional issues favour joint venturing between government, industry and utilities as the ideal arrangement for promoting CIES projects and an appreciation of the benefits of CIES and IRP to Canadian urban communities.

(ii) Government loan guarantees or risk sharing of upfront capital costs with repayment tied to revenues following project payback, are strategies worth considering by federal provincial and municipal government(s).

(iii) Municipal utilities in coordination with provincially-owned utilities should provide financial incentives to customers to help them in meeting the cost of replacing inefficient equipment with state-of-the-art equipment.

(iv) Federal and provincial government financial and staff analytical support to municipalities, and to gas and electric utilities for district energy feasibility studies is needed.

(3) Municipal Integrated Resource Planning (IRP)

A new approach to energy planning for Canadian urban communities appears to be needed--one that goes beyond the fractionalization that has characterized Canadian heat and electricity planning. To become more energy and environmentally efficient and to ensure minimal impact on the Canadian economy, Canadian policy-makers need to develop institutional mechanisms that look at the big picture. Integrated resource planning (IRP) is just such a processs. IRP integrates evaluation of demand-side and supply-side resources. With IRP, the full societal cost of energy resources is factored into the resource planning process resulting in reduced environmental affects.

The **NO_x/VOC Management Plan**, the **Green Plan**, the Canada-wide **Environment and Economy Roundtables** and **Alberta's Clean Air Strategy** are all indicative of a trend to greater breadth in decision-making participation and integrated resource planning across Canada.

To be successful, district energy must become an integral component in community planning, design, and development. By expanding a community's comprehensive planning to include heat planning, a community can create a land-use framework that is more energy and environmentally efficient and more conducive to district energy.

Recommendations

(i) Policies that **actively** support integrated resource planning in urban areas across Canada are required. Integrated resource planning, where those responsible for space heating and electric power hold joint hearings on regional energy needs, is imperative. This was the principal reason for the growth in district energy and the attendant energy-environment-economy-improvements seen in many Scandinavian countries.

(ii) In order to best manage Canada's community energy supplies and end-use energy demands, heat plans should be formulated and implemented as an integral part of a Canadian planning and development strategy.

Community heat plans should be concerned with the following:

- conservation of heat through more rational and efficient land use and building standards, and end-use technologies;
- development of alternate heat resources such as biomass, geothermal, cogeneration, waste recovery, and industrial waste heat use;
- integration of heat supply and demand planning with other traditional community planning sectors, such as housing, transportation, and employment in order to make thermal energy a key determinant in the community development process; and
- reduction of the gross fuel requirements of the community through the cumulative efforts of heat plan implementation.

(4) Promoting New Technologies

Community integrated energy systems can be instrumental in realizing the use of indigenous resources and furthering the commercial development of clean coal technologies such as Integrated Gasification Combined Cycle, Pressurized Fluidized Bed Combustion and Fuel Cells. Over the next five years, gas-powered fuel cells, that have just become commercially available, should become an economic means of cogenerating heat and electricity. Fuel cells promise essentially zero pollutant emissions and offer quieter operation than existing natural gas-turbine CHP systems.

Canada is taking a world lead in more cost effective cooling technology including the use of near freezing temperature or ice slurry in cooling distribution systems. Ice slurries can lower piping systems sizes by up to 70 percent and storage tanks for load management by a factor of over eight. These developments can help eliminate CFC using chillers and improve demand-side management (DSM) potential for electric utilities.

Recommendation

(i) Municipal City Councils should solicit support from electric and gas utilities in setting up a fuel cell demonstration for the combined generation of electricity and heat with a CIES network.

(ii) Municipalities should consider district cooling systems as part of municipal energy plans to improve load management, and as part of their environmental strategy to eliminate or better manage CFC's.

(5) Marketing and Training

An important obstacle is a shortage of skilled Canadian personnel. Builders and their tradespeople have little understanding of CIES and Canadian engineering firms and consultants are unfamiliar with European state-of-the-art hot water systems. Engineers, designers, system operators, maintenance personnel and other professionals who can design, construct and operate district energy technologies and processes are urgently required.

Recommendations

(i) Federal, provincial and municipal governments should encourage and support the training of the full range of specialists needed and the promotion of CIES benefits to a broad cross-section of Canadians--i.e., government officials, universities and community colleges, engineering consultants, environmental organizations, municipal politicians.

(ii) Representative costs for district heating and cooling systems and the application of **HEATMAP** for various test cases should be provided to consulting engineers and provincial and municipal energy planning departments.

(iii) Broad-based distribution of information directed to all potential CIES stakeholders is required on the results of CIES demonstration projects.

(6) Siting Power Plants

The Canadian public seems supportive of actions to minimize environmental impacts. Yet, the "Not In My Back Yard" (NIMBY) syndrome often limits the resolve of municipal politicians to support actions, such as CIES, which would result in an improved local environment and contribute to Canada's commitment to stabilizing greenhouse gas (GHG) emissions.

The mass media provide the vehicle for public relations activities explaining community benefits of community integrated energy networks. Certain interest groups within the community have objectives that are compatible with those of CIES development.

Recommendations

(i) Representatives of the media should be invited to all events, such as plant openings.

(ii) A relationship with community interest groups should be established in support of CIES and to overcome NIMBY.

(7) Electric and Gas Utilities Policies

Canada's energy utilities are the best equipped organizations to deal with the barriers impeding Canadian district energy development. These utilities typically operate capital-intensive systems with long-life assets and extended payback periods. They have established their credit-worthiness in financial markets and thus have reasonable access to long-term financing required to produce a reasonable return on capital-intensive projects. Utilities also work with the longer planning horizons that are required in the development of CIES and have developed, in operating their current line of business, many of the administrative, organizational and technical capabilities required to cope with the regulatory and operating requirements of district energy systems.

But, while they have the skills and knowledge necessary to develop and operate CHP and CIES projects, the utilities do not see their role as one that includes the distribution of heat or the provision of cooling. In several instances they view CIES as a competitive threat, rather than an opportunity to increase profits in another, but ancillary line of business. Until integrated resource planning (gas and electric) or environmental cost accounting become components of the Canadian regulatory process, this situation is not expected to change.

Recommendations

(i) Promote the ownership of a CIES project by gas and/or electric utilities and/or municipalities having relevant related experience, established credit worthiness, reasonable access to capital and possibly government guarantees, as a means of reducing the perceived risk of district energy projects to customers and investors.

(8) Tax Credits and Incentive Programs

Federal and provincial government(s) could accelerate CIES implementation by subsidizing project financing such that CIES projects enjoy the lower interest rates now had by regulated Canadian electric and gas utilities. A tax credit or subsidized interest rates would be appropriate near-term mechanisms for encouraging CIES until energy-environment-economy planning and regulations are revised to better account for the environmental externalities associated with Canadian energy use.

Canadian banks, trust companies and pension funds would extend such loans, provided that the difference between the rates they offer for CIES projects and going rates for other loans is financed by government subsidy. These investments would be a better risk than many bank loans to developing countries and would, moreover, support the Green Theme--"Lets All Work Together To Clean Up The Canadian Environment"--literature prominently displayed in many Canadian banks and trust companies.

Recommendations

(i) The application of tax credits such as Class 34 Capital Cost Allowance should be clearly identified and made known through extensive marketing programs.

(ii) Tax incentives, grants, provision of innovative financing, or the creation of a pricing formula for district energy that offsets retrofit costs are strategies that should be examined, for possible application to district energy development.

(iii) Financial assistance from the public sector is necessary for developers of CIES if high market penetration levels are to be achieved. This assistance could include:

- financial and analytical support (e.g., HeatMap) for district energy feasibility studies, particularly for cities and towns having the attributes likely to favor district heating;
- preferential tax treatment of private investment in district energy distribution and end-use systems; and

- assistance in project financing, both through grants and provision of low interest loans.

(iv) Financial assistance is also required to help the subscriber in dealing with the cost of retrofitting existing building stock to district energy to ensure maximum market penetration. This assistance, provided either directly by government and/or indirectly through the district energy developer, could take the form of:

- preferential tax treatment of investment in subscriber systems;
- grants to offset the cost of retrofit;
- low interest loans, with repayment schedules related to the savings in energy costs. The objective of such loans could be that the total cost of district energy to the subscriber, including loan amortization, would not exceed his cost of heating with his existing system;
- tax incentives (investment tax audits, depreciation, etc.) to encourage inclusion of central heating/cooling systems in new developments; and
- inclusion in the rate base of resource recovery capital costs and construction work in progress for CIES projects.

(9) Research and Development

There are few if any energy supply or demand reduction strategies that can be readied in the short term to meet Canada's environment challenges more effectively than advanced CHP and CIES technologies. A collaborative relationship between the federal and provincial government(s), equipment vendors and gas and electric industry is vital.

In combination with fuel cell technology, coal gasification promises to be an exciting, near term solution to urban community energy use. Compact, quiet, highly efficient, and exceptionally clean, fuel cell modules can be installed as needed on available urban sites, without the need to invest in large remote power plants and upgraded transmission lines. In addition, they respond well to load changes, can be used to correct power factor degradation in the urban grid, and offer considerable flexibility in the choice of fuel.

A major limitation to the broad application of CIES is the cost of distribution infrastructure; particularly for cooling. Research on new cooling technologies and fluids will result in greatly reduced distribution and energy storage costs.

Similarly, lower cost non-metallic piping systems are currently under development and some are at the demonstration stage.

Recommendations

(i) Research to improve the cost effectiveness of district energy systems should be accelerated so as to expand the applicability of CIES.

(ii) Considerably more dollars should be direct to fuel cell commercialization and demonstration. The applications investigated should be broad-based because fuel cells have important applications for heating, cooling, electricity generation and transportation, both urban and inter-city.

If We Do Nothing Else

Making Canadians aware of district energy and its many benefits is essential. But, this awareness must transcend broad-based information programs and CIES demonstration projects to be soundly rooted in the way Canadians assess energy-environment-economy issues and how we resolve the impacts. Critically important is the need for a new regulatory process and planning regime--one that can manage the many tradeoffs involved in assessing energy-environment-economy impacts.

Community integrated resource planning will help planners to recognize that district energy will benefit communities, utilities and customers, alike. Unless a **Integrated Resource Planning** regime is implemented which allows a more comprehensive approach to energy planning, Canada's energy utilization situation cannot be expected to become much more efficient. **District energy will never reach its potential, and the energy efficiency, environment, and economic benefits which it promises will never be realized.**

Chapter 1

INTRODUCTION

Canadian's use more energy per capita than many other Western industrialized nations. The reasons for this, in addition to Canada's severe climate and large transport distances, are small production runs, Canada's history of abundant and cheap energy supplies,[1] and a fractionalization of responsibility for energy production and energy use.[2] Canadian's must, among other steps, turn to greater energy efficiency in order to assist in maintaining Canada's share of international markets and thereby contribute to a prosperous Canadian economy.

Coupled with competitive reasons for improving energy efficiency, an even more compelling reason to improve efficiency stems from widespread concerns with the environmental impacts of acid rain, global warming and ozone depletion resulting, in large part, from energy production and use.

This report discusses an exciting technology that has the potential to contribute in a major way to solving Canada's energy-environment-economy problems--community integrated energy systems (CIES). This report reviews some of the early history of district energy,[3] instances where it is in place in selected countries, arguments supporting its accelerated development, and barriers that impede its implementation. This background information introduces various recommendations that are needed if Canadians are to reap the many benefits this technology has to offer.

This study is not intended to provide a quantitative assessment of the potential for district energy in Canada, nor does it provide a detailed technical and economic analysis of specific projects. Rather, its purpose is to assess the barriers that have limited CIES development and to isolate those factors that must be addressed in order to create an environment that is more conducive to CIES in Canada.

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[1] See Michele McLachlan, *International Comparisons: Interpreting the Energy/GDP Ratio*, CERI Study No. 41 (Calgary, Alberta: Canadian Energy Research Institute, December 1991).

[2] MSB Energy Associates, Inc., "Report on Gas Integrated Resource Planning," prepared for Ontario Energy Board, June 10, 1991.

[3] District energy and community integrated energy systems are used synonymously throughout the text.

The study's audience includes industry and government decision-makers at the federal, provincial and municipal levels, gas and electric utility producers and distributors, regulatory agencies, building owners, the investment community, engineering and architectural consultants, and all Canadians concerned with the energy-environment-economy linkage.

The essential concept underlying community integrated energy systems is one that dates back to the Romans over 2000 years ago. Community integrated energy systems distribute thermal energy, in the form of chilled water, hot water or steam, from a central plant or network of plants to individual buildings to provide space heating, air conditioning, domestic hot water and industrial process energy, typically via underground pipes.

Integrated resource planning incorporating district energy heating and cooling has never been given serious attention as a national issue because of Canada's abundance of primary energy resources and the fractionalization of responsibility that exists for providing the various components of the energy-using system. Most of Canada's energy planning and infrastructure have been based on the independent marketing of oil, gas and electricity as separate commodities, leaving competitive market forces to determine fuel market share. To some degree, Canada's high CO_2 production per capita emanates from not recognizing the potential of using CIES to tap the vast quantities of energy wasted in conventional industrial production and electric power generation.

Modern district energy technology based on hot water is now standard technology in Europe, in applications equally as challenging as those faced in Canada. In Denmark, for example, 350 district energy heating companies supply almost one-half of the space heat demand of the country. Of this, about one-half is sourced from combined heat and power (CHP), mostly supplied by capturing waste heat from large and medium-sized electric power stations. More than 35 percent of all Finnish homes are connected to district energy systems. This figure is expected to rise to 50 percent by the end of the century. Over 65 percent of Finland's district energy heating is produced in CHP plants with efficiencies of 80 to 85 percent.

The successful development of European CIES has aroused some interest in Canada and the United States and has led to limited development of systems based on European methods. While the application of European methods to Canada will not be possible in all cases due to differences in heating and cooling loads and in patterns of urban development, this technology offers the potential for major improvements in Canadian energy efficiency with attendant emissions reduction.

In fact, the combination of cold winter temperatures and high cooling requirements offers Canada even better potential for CIES than many European cities, where district energy is currently used only for space heating. In Canada, there is the potential for using central cooling facilities to replace on-site chillers, as the federal government has committed Canada to phasing out chlorofluorocarbon (CFC) production by 1995.

Opportunities for Canada from CIES include:

- better use of indigenous energy resources;
- increased opportunities for cogeneration facilities;
- increased opportunities for using industrial and municipal waste heat;
- increased opportunities for use of renewable energy resources;
- electrical peak load shaving; and
- regional energy security.

With these factors in mind, the objectives of this CERI study are:

- to review the key concepts underlying community integrated energy systems;
- to identify the benefits of district energy, including its use as a strategy to reduce greenhouse gas (GHG) emissions in Canada;
- to identify barriers to greater implementation of CIES technology in Canada;
- to propose various strategies to overcome these barriers and thereby promote greater use of CIES across Canada; and
- to demonstrate the importance of analysing energy-environment-economy issues together rather than separately.

Chapter 2

OVERVIEW OF DISTRICT ENERGY

2.1 What is District Energy?

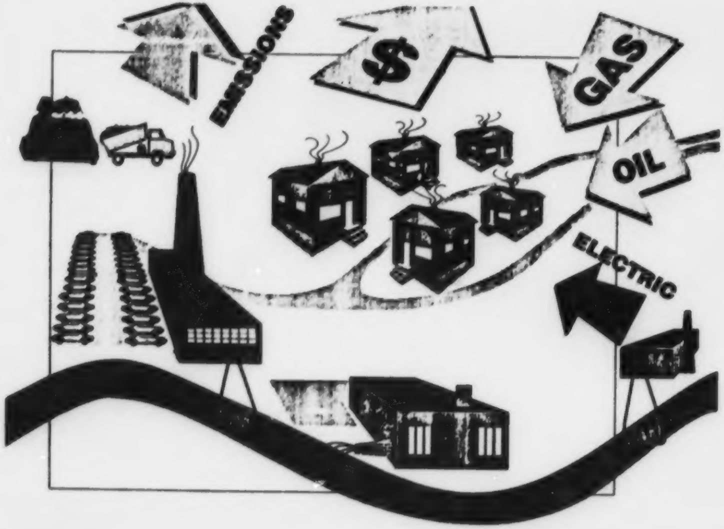
In the district energy process, energy is distributed to individual buildings via underground pipelines. District energy is analogous to electricity production where dedicated transmission and distribution lines distribute electric power from a central electrical generating plant and non-utility generators to final consumers. In a district energy system hot water, steam or chilled water produced at various locations is piped underground to buildings in the area for their space heating, domestic hot water, cooling or industrial process uses (see Figures 2.1 and 2.2). Users connected to the community integrated energy system (CIES) extract energy from the transfer medium rather than generating the useable energy on site at a facility in each building (see Figure 2.3).

The aim of CIES is to satisfy the heating and cooling needs of a group of energy users from one or more central production sources. This is in contrast to the heating and cooling systems associated with individual buildings. Users of the system can be large or small consumers of energy, and they may include residential, commercial, institutional and industrial users. District energy may be viewed as a facilitative technology as it provides the means for achieving a more efficient use of available energy sources. Its use often provides a larger heat load that can lead to economies of scale in the heating plant or permit a number or combination of fuel types to be used to maximize cost effectiveness and flexibility.

For example, many industrial companies recover waste heat from their processes to heat their factories. Some companies, typically refineries and large chemical firms, generate more heat than they can use. This surplus heat can often be sold for use in a district energy system, a potentially profitable arrangement for all parties.

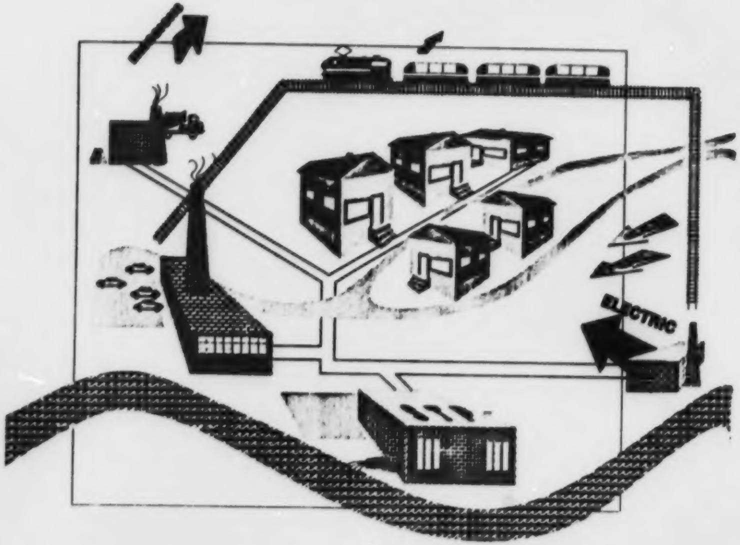
With a district energy system the consumer still has control over the room temperature but instead of having an oil or gas-fired boiler or chiller in the building, a heat exchanger or heat pump is used to convert the steam or hot or chilled water into heating, cooling or

FIGURE 2.1
CONVENTIONAL ENERGY SYSTEM


EMISSIONS
$
GAS
OIL
ELECTRIC

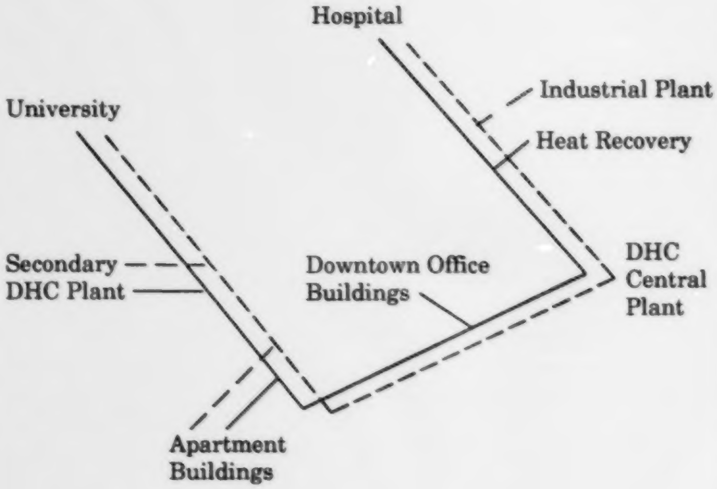
SOURCE: Canada Centre for Mineral and Energy Technology.

FIGURE 2.2
DISTRICT ENERGY SYSTEM



SOURCE: Canada Centre for Mineral and Energy Technology.

FIGURE 2.3
COMMUNITY INTEGRATED ENERGY SYSTEM SCHEMATIC


Hospital
Industrial Plant
University
Heat Recovery
Secondary
DHC Plant
Downtown Office
Buildings
DHC
Central
Plant
Apartment
Buildings

SOURCE: International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *District Energy Sstems, Promotional Manual for System Developers and Operators, Second Draft*, November 1991, p. 3.

process energy for residential, commercial, medical or industrial users. At each subscriber location there is also a meter to measure the amount of heat consumed by each subscriber.

Depending on community needs, the thermal production system can be either a centrally located facility or several interconnected plants. District energy systems are adaptable to a wide variety of fuel types. This flexibility can benefit the country and the consumer by providing thermal energy at stable and competitive prices and reducing dependence on scarce or imported fuels. There are district energy systems that use coal, oil, and gas-fired boilers; garbage incinerators; wood chip fired boilers; nuclear power plants; geothermal wells; heat pumped from sewage effluent; and heat produced as a by-product of electrical generation, termed cogeneration or combined heat and power (CHP).

2.2 History of District Energy[1]

Piped heating systems are a very old concept. Nearly 2000 years ago, the Romans circulated warm water through open trenches to provide heating for buildings and baths in Pompeii. In many places it is still possible to see how the heated water was circulated from home to home through a network of trenches that went through the cellars of the buildings (see Figure 2.4). Hundreds of years later, in Chaudes-Aigues Cantal in France, warm water was distributed through wooden pipes that are still used today.

In 1877, Birdsill Holly pioneered the first commercial district heating system in the U.S. in Lockport, New York. He used a boiler in his cellar as the central heat source and built a loop consisting of steam pipes, radiators, and condensate return lines. The system began with fourteen customers and by 1880 the system served several factories as well as residential customers and had extended to a three-mile loop.

In 1893, the Municipal Council Building in Hamburg, Germany, was receiving heat from a central power station. In 1900, to minimize risk of fire damage to valuable art treasures, government

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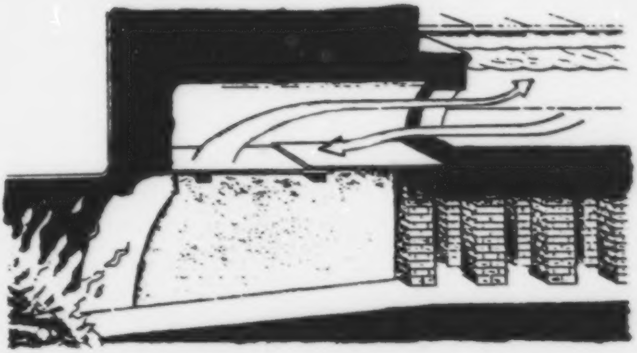
[1] Gordon R. Bloomquist, John T. Nimmons and Kevin Rafferty, *District Heating Development Guide, Legal, Institutional, and Marketing Issues, Volume 1* (Olympia, Washington: Washington State Energy Office, October 1988), pp. 1-3.

FIGURE 2.4
A TRIP TO THE BATHS

HEATING THE BATHS
Fires stoked by slaves from outside the bath building sent hot air under the floors and through hollow tiles in the walls to chimneys in the roof. The floors and walls became so hot that people inside had to wear wooden clogs to avoid burning their feet. The fires were also used to boil water in tanks and to heat pools, as seen below.



SOURCE: Simon James, *Ancient Rome*, Toronto, 1990, p. 38.

buildings in Dresden, Germany, were linked to a central heating system.

By the turn of the century, district heating systems were being established or expanded in most large cities in the United States. Heat for many of these systems was provided by the electrical generating plants that were being established throughout the country. The heat was in the form of exhaust steam from these facilities.

The same was true in Europe and Scandinavia. In Denmark, the first district heating system was established in Frederiksberg (a suburb of Copenhagen) in 1891. The heat was provided by an electrical generating plant and supplied a hospital and several government buildings. Throughout the first half of this century, district heating prospered in the U.S. and to a lesser extent in Scandinavia and Europe.

However, following the Second World War, the U.S., Europe, and Scandinavia went in different directions. In the U.S., rapid urban growth as well as economics of scale forced most major electrical generating plants to locate outside urban areas. The cost of building central heating plants solely to supply district energy systems was prohibitively expensive and an abundance of inexpensive electricity, oil, and natural gas spelled the demise of many district energy companies. In Europe and Scandinavia, where electricity and natural gas were not as abundant as in the U.S., district heating prospered. More and more cogeneration plants were built to supply an ever increasing demand for electricity and to take advantage of the synergies of integrating all community heat sources and sinks.

The 1970s, however, brought major changes to district heating. The oil shortages of the early and late 1970s caused countries such as Sweden and Denmark, which depended upon imported oil to fuel nearly 90 percent of their district heating systems, to look at alternatives such as garbage incineration, waste heat, and renewable resources. Several countries initiated aggressive government programs in support of new and expanded CIES systems. The oil crises of the 1970s also caused a renewal of interest in district heating in the U.S., but to a lesser degree in Canada where the population was sheltered from the sharp increase in oil prices by government policy.

2.2.1 Current Status and Trends

Estimates of the level of market penetration of district energy systems are not available on a comparable basis for the major countries of the world. The estimates in Table 2.1 have been assembled to indicate the order of magnitude of market penetration for several countries where district energy has achieved a significant level of market acceptance.

TABLE 2.1

CROSS COUNTRY COMPARISON
OF DISTRICT ENERGY

Country	Production of District Heating in 1989 (PJ)	Share of District Heating in the Total Heat Market (percent)
France	90.0	4
West Germany	190.3	5
United States	300.0	3
Sweden	128.5	34
Denmark	82.9	44
Finland	79.9	43

SOURCE: International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *District Energy Systems, Promotional Manual for System Developers and Operators*, Second Draft, November 1991, p. 14.

As Table 2.1 shows, in Denmark, Finland and Sweden, district energy is an important force in the building heating market. In the U.S., by contrast, district energy market penetration is low.

The factors that influence the relative competitiveness and market penetration of district energy are many and varied. Several factors are, however, broadly based:

- District energy systems require large initial capital investment with returns spread over a lengthy period. Thus, few opportunities exist for investment in district energy systems that yield short paybacks for their sponsors. The economic advantages for new district energy systems, when based on calculations of project costs and returns, are in fact, marginal in many cases. Only when economic, environmental and other social benefits are included in the assessment do most new district energy systems become attractive.

- Concerns over the "greenhouse effect" and other environmental issues appear to be increasing. Although the policy responses of governments are only now being formulated, it is likely that, in at least some countries, the adoption of combined heat and power systems will be encouraged.

- Associated with environmental concerns are the increasingly difficult siting problems for new power plants. The result, in North America and other countries, is a growing interest in promotion of the efficient use of electricity in order to delay the requirement for new generating capacity. It is expected that regulatory commissions will encourage a large number of electric utilities to offer subsidies for the installation of efficient lighting, motors and other equipment.

- In markets where cooling requirements are high, many opportunities will be explored for the establishment or expansion of district cooling networks. The activity will likely be the greatest where a compatibility with electric utility demand reduction programs exists.[2]

In North America, it is expected that a large number of assessments will be conducted, particularly for district cooling opportunities, and that numerous projects will be initiated by the end of the decade in existing urban areas and new communities.[3]

2.3 District Energy Configurations

District energy systems can be established in a wide variety of configurations. A central plant, for example, may supply several buildings under common ownership, such as a university or office complex. This approach is often called **group heating**. Many group heating systems are in place. The most common applications for group heating systems are:

- Office Complexes
- Apartment Building Complexes
- Hospitals
- Colleges and Universities
- Military Bases and Airports
- Correctional Facilities

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[2] International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *District Energy Systems, Promotional Manual for System Developers and Operators*, Second Draft, November 1991, p. 2.

[3] Ibid., p. 14.

Group heating systems are of particular interest to district energy developers because it may be possible to link two or more group systems together as the basis for a **municipal district heating system**. The group systems can be seen as "satellites" that represent a logical first step in the evolution of the municipal district energy system. A municipal system can serve a variety of facilities, including office, apartment and institutional buildings. As the system is expanded, it may use existing heating plants or new plants can be installed as required.[4]

As a result of historical factors, some municipal systems serve only the largest buildings in downtown areas. In other cities, notably in Sweden, Denmark and Finland, municipal district energy systems are much more extensive, serving areas with sizable heating requirements that extend several kilometers from the downtown commercial centers.[5]

When a district energy distribution network is expanded beyond a concentration of downtown buildings, it can often include additional energy sources. These sources may include municipal solid waste (MSW) incineration or industrial waste heat. Based on technical feasibility and economic attractiveness, these sources may be integrated cost-effectively into the expanding municipal system. Such integrated systems are called **community integrated energy systems**.

The Malmo, Sweden system, described in Part II is a good illustration of the CIES concept.

Features of the Malmo system include:

- The municipal utility introduced district heating in 1951, the second district energy system in Sweden. The utility also operated the electricity and gas distribution systems.
- The system serves approximately 8000 subscribers with a nominal heat load of 1500 megawatts of thermal energy (MW_{th}).
- From its origin, the system used CHP plants to meet the community's electricity as well as heating requirements.

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[4] Ibid., p. 2.

[5] Ibid., p. 4.

- Initially, the district energy system was heavily dependent on oil. Through investment in various energy sources during the 1970s and 1980s, this dependency has been essentially eliminated.

- In 1989, the following energy sources were utilized to provide the 2500 GW.h of delivered thermal energy:

Natural Gas	36 percent
Refuse incineration	22 percent
Industrial waste heat	22 percent
Coal	12 percent
Oil	2 percent

- In 1991, the Malmo system was purchased from the municipal government by a privately-owned electric utility that serves southern Sweden.

In communities where buildings have significant cooling requirements, such as in many parts of North America, **district cooling systems** may be established. A common method for providing district cooling has been based on the installation of steam absorption chillers at buildings connected to a steam-based district heating system. With this method, a single piping network can deliver energy for both heating and cooling. The New York City district energy system operated by Consolidated Edison is an example of this approach. With other designs, district cooling networks can be separated from district heating distribution systems. For example, the chilled water network in Indianapolis, Indiana is totally independent of the district heating network.[6]

In other cases, the district energy piping distribution networks can be integrated. The Hartford, Connecticut district heating and cooling system operated by Energy Networks Incorporated was started in 1962 and currently serves over 70 percent of the buildings in downtown Hartford. Through existing and proposed networks, the system is expanding beyond the downtown area to serve many state government buildings. A natural-gas-fueled CHP plant, completed in 1990, produces hot water and chilled water for the district energy system as well as electricity for the grid.

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[6] Ibid., pp. 4 and 5.

2.4 System Ownership and Mandate

In addition to the differences in the way district energy systems are configured, significant differences also exist in ownership structures and the mandate of CIES managers.

- **Ownership:**

  Most municipal district energy systems are owned and operated by public or non-profit organizations. These organizations report either directly or indirectly to municipal government officials. A sizable number of municipal systems, however, are privately owned, either by firms specializing in the operation of municipal district energy systems or by electric power utilities.[7]

  Ownership of group systems can be either private, such as in the case of an office building complex, or public, as in the case of institutions such as universities or hospitals. Alternatively, ownership might be shared--central plants privately owned with heat distribution by publicly-owned municipal utilities.

- **Objectives and Mandate:**

  Financial objectives can vary among district energy systems. Some seek only to recover operating costs or minimize annual expense budgets. Other CIES seek to achieve profit and return on investment targets.

  For some systems, organizational mandates may encourage expansion of the district energy system wherever feasible. In other cases, particularly group systems, the mandate for system managers limits operation to the existing network.

2.5 Technology Options

District energy technology is essentially a facilitative mechanism linking available energy sources with energy requirements in a community. Many choices are available that offer district energy systems the capability to adapt to changes in the availability and cost of energy sources, the magnitude and location of thermal energy demand, and government policy initiatives in the energy and environmental areas. Furthermore, research and development continues to bring new and improved technologies to the market that increase the cost effectiveness and flexibility of CIES.[8]

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[7] Ibid., p. 6.

The heat plant may consist of any combination of heat-only units, units that produce both heat and electricity, waste heat recovery units, and auxiliary heat units for standby and peaking purposes. In addition, existing power plants can be retrofitted for CHP and thermal storage devices can be used to help meet peak load requirements. There are also a number of emerging heat production technologies including fluidized bed combustion, coal gasification, coal-fired gas turbines and fuel cells, that have potential for application to community integrated energy systems.

The heat plants are not necessarily located at a single site, and may provide heat to the system from a number of locations. The plants produce thermal energy for the transmission and distribution networks in the form of either steam, hot or chilled water.

Hot water is generated at the district energy plant using a conventional boiler, cogeneration system, waste heat boiler or other sources of energy. Many different heat sources can be used for low and medium temperature hot water district energy, including industrial waste heat, geothermal, nuclear, and heat pumps, in addition to conventional boilers or CHP.

Because electricity generation is reduced when higher temperature hot water (or steam) is required, CHP plants are normally sized only for the base load, with peaking boilers used for elevating the temperature when needed.

2.5.1 Energy Conversion Technologies

Several types of designs are utilized at central plants to convert energy sources into useful energy that is distributed to buildings connected to the district energy system.

2.5.1.1 Combined Heat and Power Plants

In CHP plants, large boilers utilize various types of fuels to produce high pressure steam. This steam drives a turbine that generates electricity. The steam coming out of the turbine can then be distributed directly to the CIES network, condensed in a heat exchanger to heat water for distribution, or utilized to drive chillers.

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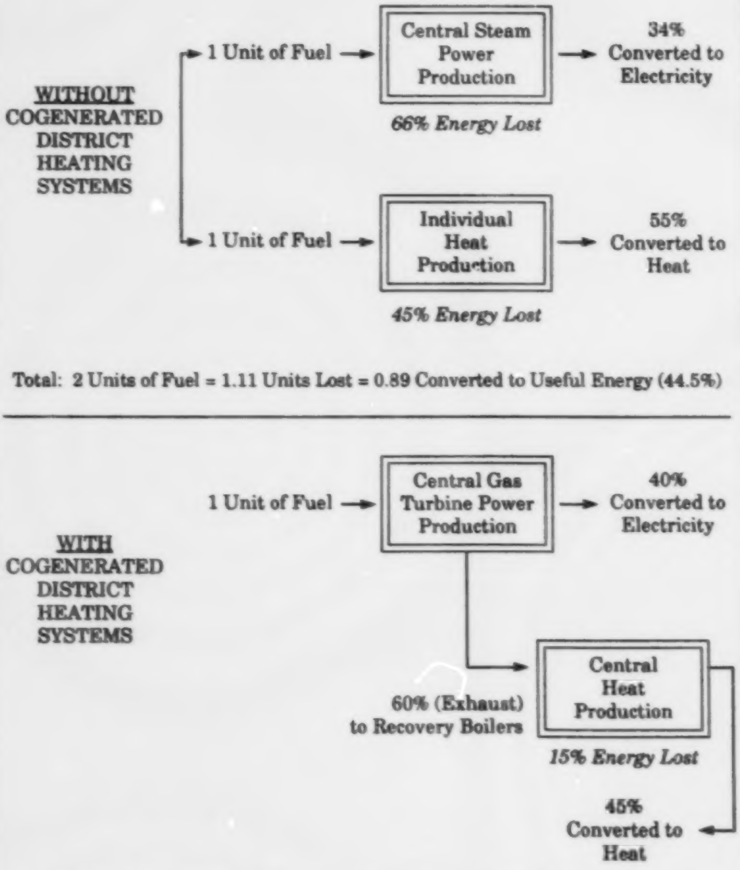
[8] Ibid., p. 9.

The advantage of CHP is the potential it offers for achieving substantial energy cost savings. This is primarily because it is a very efficient means of producing both electricity and thermal energy. In a condensing power station, the condenser is cooled with water from a river, a lake, the sea or cooling towers. In a cogeneration plant, steam turbines can be used in the same way as in a power station. However, the water for cooling will be used in the district energy network to provide space heating in buildings.

Because the heat normally rejected by a power generating system is used to produce steam or hot water for space heating, overall energy conversion efficiencies of more than 80 percent are typical of many cogeneration systems. This compares to an overall conversion efficiency of only 35 to 38 percent for conventional power generating stations that reject heat directly into the environment. Efficiencies may be 30 percent or less for nuclear power plants. This improvement in energy conversion efficiency leads directly to a reduction in the use of coal, oil or natural gas. Compared to separate on-site systems for production of heat and electricity, fuel requirements and the subsequent emission of pollutants are **significantly** reduced per unit of useful energy produced with CIES. More energy value can be obtained from each dollar spent to cogenerate heat and electric power than if it had been spent on the separate purchase of electricity and heating fuel.

The improvement in energy efficiency is illustrated in Figure 2.5 where the overall efficiency increases from 44.5 percent without cogeneration to 85 percent with cogenerated heat and electric power. Table 2.2 indicates the energy efficiencies of cogeneration for conventional pulverized coal fitted with Flue Gas Desulphurization, Pressurized Fluidized Bed Combustion (PFBC) and PFBC/gasification. Total efficiency ranges from 77 to 84 percent for coal-fired power stations dedicated to the production of both district energy and electric power production.

FIGURE 2.5
HARNESSING WASTED ENERGY WITH COGENERATION AND DISTRICT ENERGY


WITHOUT
COGENERATED
DISTRICT
HEATING
SYSTEMS
1 Unit of Fuel
Central Steam Power Production
34% Converted to Electricity
66% Energy Lost
1 Unit of Fuel
Individual Heat Production
55% Converted to Heat
45% Energy Lost
WITH
COGENERATED
DISTRICT
HEATING
SYSTEMS
1 Unit of Fuel
Central Gas Turbine Power Production
40% Converted to Electricity
60% (Exhaust) to Recovery Boilers
Central Heat Production
15% Energy Lost
45% Converted to Heat

Total: 2 Units of Fuel = 1.11 Units Lost = 0.89 Converted to Useful Energy (44.5%)

Total: 1 Unit of Fuel = 0.15 Units Lost = 0.85 Converted to Useful Energy (0.85%)

SOURCE: Trigen-London District Energy Corporation.

TABLE 2.2

CHP EFFICIENCIES AND POWER-HEAT RATIOS FOR COAL-FIRED SYSTEMS[a]

System	Power	Heat	Efficiency	Power/heat ratio
	(percent)			
Pulverized coal-FGD	28	54	82	0.52
PFBC	32	52	84	0.62
PFBC/gasification	39	38	77	1.02

SOURCE: Irene M. Smith and Kelly V. Thambimuthu, *Greenhouse Gases, Abatement and Control: The Role of Coal* (London, U.K.: IEA Coal Research, June 1991).

Combined heat and power provides many benefits such as energy cost savings, improved reliability of electrical energy supply in the form of standby power, and enhanced process flexibility. Potential revenues can also be realized from the sale of electricity to utilities or from the sale of surplus steam and hot water to neighboring users.

Combined heat and power district energy plants came into use early in the twentieth century. They used the exhaust steam from small dual-purpose power plants to heat buildings in the nearby business district. Their use increased until the late 1940s, when inexpensive oil and natural gas were introduced for space heating. At the same time, electric utilities started building large condensing-electric power plants in rural areas. Because it was not economic to transport steam over long distances, the older, smaller cogeneration units were retired, calling a halt to district energy development.

In Finland, Denmark, and throughout much of Europe, CHP is a common source of district heating (see Part II). In the United States, Hartford, Connecticut, and James Town, New York, have recently completed construction of modern district energy systems based on CHP, and in Tacoma, Washington a fluidized bed cogeneration plant that will use municipal solid waste, coal, wood waste, and other waste fuels has recently been constructed, cutting the volume of landfill waste by 70 to 80 percent.[9,10]

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[9] Gordon R. Bloomquist, John T. Nimmons and Kevin Rafferty, *District Heating Development Guide, Legal, Institutional, and Marketing Issues, Volume 1*, p. 23.

[10] Patrick McCorty and Thair Jorgensen, "Fluidized Bed For Resource Recovery," *Independent Energy* (October 1990).

The thermal energy available from a CHP plant will usually be in the form of either high or low pressure steam. However, if the distribution of hot water is chosen, the use of heat exchangers at the production plant allows the heat to be transferred to a hot water system. Thus turbine backpressure is very low and the production of electricity is maximized.

In recent years, more and more attention has been given to the possibility of cogenerating electricity and heat in small-scale (less than 25 MWe) plants using either solid fuel steam turbines or gas turbines. A 1986 Swedish investigation has found that the small-scale plant can compete with coal condensing power stations in the production of electricity.

The St. Paul, Minnesota, district energy system is one of the most often cited success stories. In St. Paul, an older steam distribution system has been replaced by a modern hot water system. The hot water production comes from coal and oil/natural gas boilers located in a CIES production plant located adjacent to the central business district.

Because district energy uses higher temperatures than coolant water in condensing stations, the amount of electricity from a cogeneration plant is somewhat lower than in a corresponding condensing plant using cooler water. To maximize power production in a cogenerated heating system, therefore, temperature as low as possible is needed for the heat transfer medium. Electricity losses may be as low as 7 percent for low temperature hot water supply to over 50 percent for high pressure steam.

2.5.1.2 Heat Only Plants

Many district energy plants produce only thermal energy in the form of steam or hot water from the combustion of various fuels. The determination of whether a central plant will be CHP or heat only is usually highly dependent on pricing terms and conditions offered by the electric utility for the electricity that would be produced by a CHP plant.

2.5.1.3 Thermal Storage

Many systems incorporate one or more large storage tanks of hot or chilled water that provide additional capacity. Thermal storage adds flexibility and emergency/peaking capability to meet demand.

2.5.1.4 Technology Development

Central plant technologies are advanced and well proven. Development work continues to improve combustion efficiencies and reduce the level of undesirable emissions, such as SO_2 and NO_x. Progress is also being made in improving the cost effectiveness of central plants that utilize non-conventional energy sources, such as the combustion of biomass and utilization of large heat pumps for water energy sources.

The concept of the block central (local district heating system) is one that is ideally suited to the use of a small fossil fuel-fired boiler and ideally suited to the development of a new, or expansion of an existing, district energy system. Start small...think big...think link has guided energy planners throughout Scandinavia.[11] In Sweden, over 6000 block centrals rely on small fossil fuel boilers. The heating of block centrals with a central boiler allows for new construction to be designed so as to be easily connected to a community-wide district energy system. As a new area is built up, several block centrals can be interconnected and eventually the entire area can be connected to the CIES.

In both Sweden and Denmark, the use of fully automated fossil fuel production plants has been or is becoming an integral part of most community district energy systems. Some of these units are used as baseload units, while others are used only for peaking and/or back-up purposes. Although coal is becoming the preferred fuel due to cost and recent advances in automated coal handling technology, most units retain the capability to use oil and natural gas.

2.5.2 Biomass Boilers

Biomass fuel, once a major fuel for district heating, is making a strong comeback.

In Sweden and Finland, peat is becoming a major biomass fuel and advances in harvesting, drying, and handling have greatly improved its cost competitiveness for use in district energy systems. In Denmark, straw is becoming an extremely important fuel for district heating. At present, 20 plants are in operation and consume more than 100 000 tons of straw per year. Over the next several years, another 20-25 plants are planned, increasing the consumption of straw to 240 000 tons per year. In some plants, the straw bales are burned directly in the furnace. In other types of plants, the straw is first shredded before burning. The straw bales are usually 500 kilograms each and most of these plants operate unmanned.[12]

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[11] Gordon R. Bloomquist, John T. Nimmons and Kevin Rafferty, *District Heating Development Guide, Legal, Institutional, and Marketing Issues, Volume 1*, p. 24.

In the United States, the incineration of municipal solid waste has become a major energy source for district heating. Baltimore Steam has, in fact, been able to reduce the cost of district energy to the consumer by about 25 percent because of the availability of steam from a modern waste-to-energy incinerator.

In Malmo, Sweden, over 60 MW_{th} is provided to the district energy network from the Sydsav incinerator. In Denmark, over 40 waste incineration plants have been established during the past three decades with an annual capacity of 1.5 million tons of refuse. Most of the plants supply heat to the local CIES. Other fuels derived from biomass materials include landfill gas and digester gas. Both are being used extensively in Scandinavia in the production of hot water for district heating.

2.5.3 Nuclear Plants

A great amount of research into the use of nuclear energy for district heating has been underway in both Canada and Sweden. The Swedish concept, a small, self-regulating reactor, would produce hot water for district heating. The Canadian reactor, also self-regulating, would shut down as temperatures reached the boiling point. The concept of using nuclear energy for district energy appears promising but anti-nuclear sentiment, together with the inability of the nuclear systems to compete economically with fossil fuels, has prevented further development in both Sweden and Canada.[13]

2.5.4 Geothermal Resources

The Soviet Union, Hungary, Iceland, France and the United States have been leaders in the use of geothermal energy for district energy. Unlike fossil and biomass-fired systems, geothermal systems are usually designed as baseload systems with peaking and backup requirements met through the use of thermal storage and fossil fuel or electric boilers. If properly designed, the geothermal portion of the system can provide 80 to 85 percent of annual energy consumption while meeting less than 50 percent of the peak demand. In order to meet peak demand with geothermal, the number of wells would have to be doubled with a corresponding increase in the diameter of the distribution piping system.

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[12] Ibid., p. 25.
[13] Ibid., p. 26.

2.5.5 Industrial Waste Heat

Another major potential source of thermal energy for district heating is industrial waste heat. Major producers of industrial waste heat include the pulp and paper industry, cement industry, chemical plants, petroleum refineries, glass working industry, ore smelters, and steel mills. Most of the surplus heat available from industry can be used in a district energy system, either directly or through the use of heat pumps.[14]

One of the major drawbacks to expanded use of industrial waste heat has been accessibility to higher-grade heat sources. Also, the vast quantities of available heat have been at temperatures too low to be used directly. The development of large (1-30 MW_{th}) heat pumps that can take advantage of the large quantities of waste heat below 38°C (100°F) has allowed energy planners to seriously consider the use of this abundant thermal resource.

In the Swedish city of Landskrona, industrial waste heat has become the primary heat source for the district energy system and the availability of the CIES system has, in turn, been a major attraction to industries with waste heat to sell. In Halmstad, Sweden, waste heat from a glass plant supplies most of the heat to a newly developed residential area with nearly 1500 dwelling units.[15]

In the U.S., Tacoma, Washington, is evaluating the feasibility of low-temperature (less than 35°C) waste heat from a pulp and paper plant and high-grade heat from chemical plants for a district energy system.

The development of plasma technology has also provided an excellent source of industrial heat for district heating. In the plasma process, electrical energy is transformed into heat energy in a gaseous environment. This is done by passing the gas through an electric arc maintained between two electrodes. In and around the electrical arc the gas is ionized (converted to a plasma) and can absorb great quantities of heat. The gas leaving the generator therefore has a very high heat content, much higher than can be achieved by conventional means. The plasma generator has an efficiency of 82-87 percent. Because some kind of solid or liquid fuel is transferred to a clean fuel gas, and because for thermodynamic reasons only part of the gas can be used in the industrial process, the remaining gas is available for use as a fuel in a boiler for district energy purposes. Since the gas is much lower in sulphur than either coal or oil, and there is no ash in the gas, there is also a major environmental benefit to be gained from using the plasma process.

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[14] Ibid., p. 27.
[15] Ibid., p. 28.

Applications of plasma technology include recovery of iron, zinc, and lead from steel mill bag house dust, production of sponge iron from iron ore, and the transformation of municipal and industrial waste to a clean fuel gas. The introduction of plasma technology offers higher energy efficiency, cost savings, environmental benefits, a continuous source of clean heat for district heating, and a source of new employment and economic growth.

2.5.6 Heat Pumps

Heat pumps are capable of boosting the latent thermal energy found in low temperature sources up to temperatures suitable for space conditioning and water or process heating. Figure 2.6 is a simplistic illustration of the "boosting" that occurs in a heat pump. The coefficient of performance (COP) is the ratio of driving energy to heat output, and is dependent upon the temperature differential between input temperature and output temperature. The greater the difference, the lower the COP.[16] Figure 2.7 provides a more detailed description of a heat pump's components and operation using hydrothermal sources.

A heat pump operates by transferring the heat in a low temperature source to a refrigerant through an evaporator (heat exchanger). The refrigerant when heated is converted to a gas and then heated further through compression. The hot gas is then condensed, returning to the liquid state and giving off its heat in the condenser to a secondary fluid, e.g., treated water that is then circulated for heating. The refrigerant is then returned via a pressure-reducing valve to the evaporator where the process is repeated.[17]

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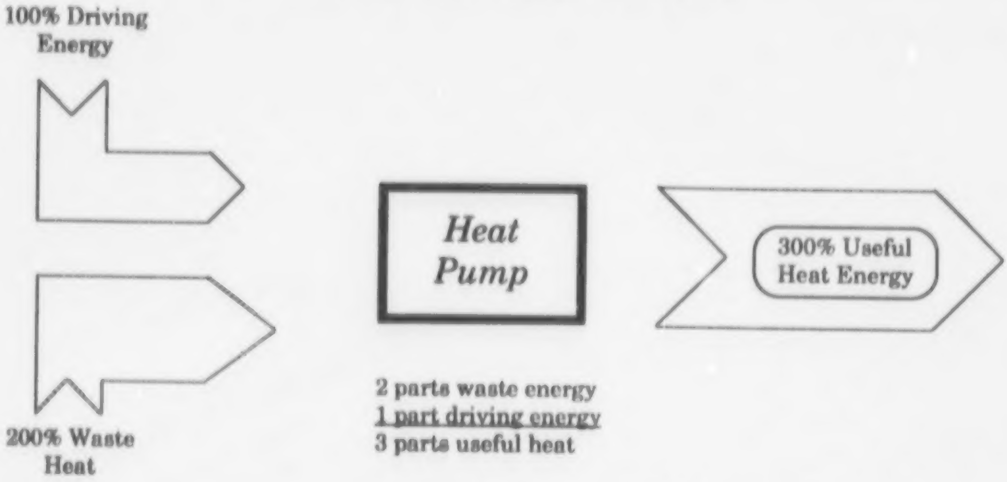
[16] Ibid., p. 29.
[17] Ibid., p. 31.

FIGURE 2.6
THE HEAT PUMP CONCEPT

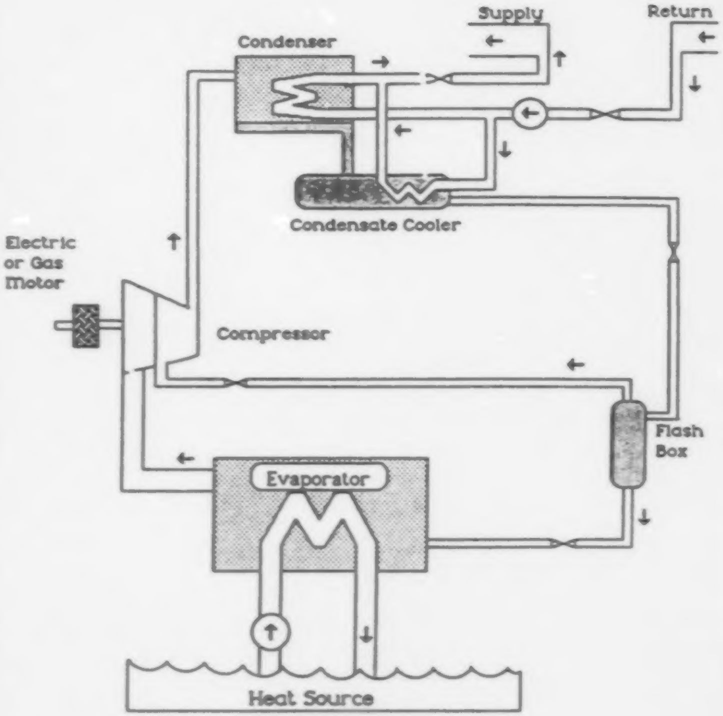

100% Driving Energy
200% Waste Heat
Heat Pump
300% Useful Heat Energy

2 parts waste energy
1 part driving energy
3 parts useful heat

$$\text{Heat pump C.O.P.} = \frac{\text{Useful heat energy}}{\text{Driving Energy}}$$

SOURCE: Washinton State Energy Office, *District Heating Development Guide*, October 1988, p. 29.

FIGURE 2.7
LOW TEMPERATURE WATER SOURCE HEAT PUMP


Supply
Return
Condenser
Condensate Cooler
Electric
or Gas
Motor
Compressor
Flash
Box
Evaporator
Heat Source

SOURCE: Washington State Energy Office, *District Heating Development Guide*, October 1988, p. 30.

Because heat pumps can be used to boost the temperature of hydrothermal sources to temperatures applicable for use in a district energy system, their use has opened up the use of resources such as low temperature geothermal, groundwater, sea water, lake water, sewage effluent, and industrial waste water.

The first major use of heat pump technology for district heating in the state of Washington was in the city of Ephrata. A 30°C geothermal well served as the source for a 1 MW_{th} heat pump installation that supplies heating and cooling to the Grant County Courthouse and the Courthouse Annex. The system operates with a COP of 5.8 in the heating mode and about 4.0 in the cooling mode.

In Lund, Sweden, a 24°C geothermal resource supplies nearly 50 MW_{th} to the city's community integrated energy system. The two heat pumps (18 and 30 MW_{th}) operate with a COP of approximately 3.3 and supply approximately 80°C water to the district energy network.

In Stockholm, Sweden, a floating heat pump plant, generating 100 MW_{th}, uses four heat pumps and sea water as its heat source. Heat is supplied to the Stockholm CIES and although the temperature of the heat source can drop to as low as 4°C in the winter, the heat pump station operates with a COP of about 3.0.

Heat pumps operate most efficiently when the differential between the source temperature and the output temperature is as small as possible. Most heat pump systems are designed to meet 50 percent or less of peak demand with the remainder being furnished by a fossil fuel or electric boiler that can also serve as an emergency or stand-by unit. Although the heat pump supplies 50 percent or less of the peak demand, it can supply 80 percent or more of the total annual energy requirement and thereby operate at or near full capacity year round with better efficiency and economy as a result.

Heat pumps are also beginning to play a major role in the development of thermal storage systems that utilize solar energy or low temperature waste heat sources.[18]

2.5.7 Thermal Storage

Thermal storage is rapidly becoming an integral and extremely important aspect of district energy production. Thermal storage is essential to efficient utilization of solar energy, industrial waste heat, and combined heat and power for district heating. Both short-term (diurnal, weekend, weekly) and seasonal storage may be used depending upon the requirements of the district energy system and the characteristics of the heat source. Thermal storage can be used to meet peak demand or to bridge the time gaps between system demand and availability.

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[18] Ibid., p. 32.

If electricity and CHP-based district energy system demands were constant or inversely related, the utilities could easily design or adjust operation to accommodate consumers. However, this is not normally the case. During the coldest or hottest periods, electricity and heat/cooling demand tend to have similar seasonal peaks. Europeans have solved this problem by installing direct-fired boilers to supplement steam load supply from power plants during peak conditions. For intermediate seasons (spring and autumn), the power plants run at reduced loads producing mostly electricity with minimal steam generation for heating and air conditioning. Figure 2.8 shows the components of a district energy system schematically.

Because most district energy systems require large quantities of thermal energy, the storage medium must have a high heat capacity, be environmentally acceptable, and be reasonably inexpensive. Most storage systems therefore rely on water as the storage medium although rock may be used as well.

Another important characteristic of a storage system is its ability to contain the storage medium by providing boundaries against water and heat flow from the facility. Containment can be provided by above or below ground tanks, rock caverns (natural or man made), geologic structures, geologic formations, and lakes or ponds. The containment must provide structural integrity, good thermal insulation, and, as with the storage medium, be inexpensive.[19]

Short-term storage can be extremely important to achieving maximum thermal as well as electrical output from a cogeneration facility. Where peak demand for electricity and thermal energy coincide, the availability of sufficient short-term storage, usually in the form of above ground steel tanks, allows for maximum electrical generation while the thermal peak can be met with heat produced and stored during off peak periods.

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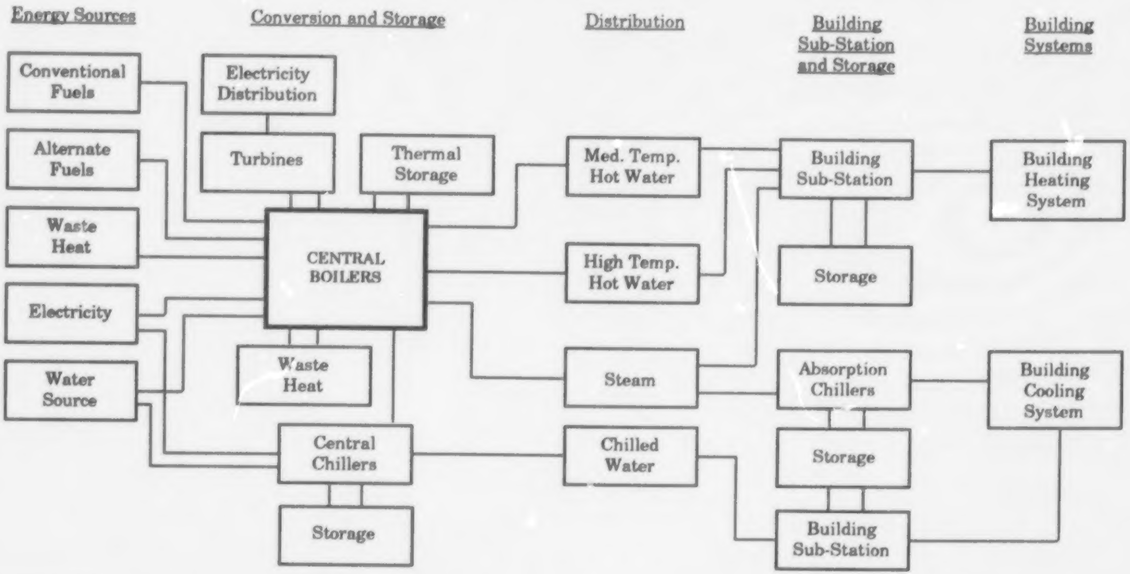
[19] Ibid., p. 33.

FIGURE 2.8
COMPONENTS OF DISTRICT ENERGY SYSTEMS


Energy Sources
Conversion and Storage
Distribution
Building Sub-Station and Storage
Building Systems
Conventional Fuels
Alternate Fuels
Waste Heat
Electricity
Water Source
Electricity Distribution
Turbines
Thermal Storage
CENTRAL BOILERS
Waste Heat
Central Chillers
Storage
Med. Temp. Hot Water
High Temp. Hot Water
Steam
Chilled Water
Building Sub-Station
Storage
Absorption Chillers
Storage
Building Sub-Station
Building Heating System
Building Cooling System

SOURCE: IEA Promotional Manual, Draft, December 1991.

In Odense, Denmark, the CHP plant has a heat accumulator of 12 000 cubic metres in order to balance the need to supply electricity to the island of Fyn and thermal energy to the city of Odense. The availability of the storage tank enables the CHP plant to run in full condensation mode when peak electrical generation is required without a reduction in the delivery of heat.

Long-term or seasonal thermal storage usually involves storage in aquifers, open rock caverns, or bore holes in rock. The temperature at which the energy is stored can vary from 20-40°C for solar systems and some waste heat systems to 80-90°C for systems based upon CHP or municipal waste incineration.

An apartment complex in a suburb of Stockholm, Sweden, uses 25 drill holes each with a length of 80 metres to store solar energy in solid rock by heat conduction. During the summer, heat is extracted from the glazed solar court and circulated to the rock storage area below the complex by way of heat pumps. In winter, the heat is taken from the storage by circulating fluids to the heat pumps to produce hot water and space heating.

In Salt Lake City, Utah, an office building uses a four well arrangement to supply both heating and cooling. During the summer months, water is withdrawn from two of the wells and, through the use of heat pumps, heat is extracted from the building and the water (serving as the heat sink) is returned to the two injection wells. During the winter, the system is reversed and the now somewhat warmer water provides for the space heating of the building.

Thermal storage can often be an attractive addition to a district energy heating system and a solution to many of the problems associated with heat demand and availability when cogeneration, industrial waste heat, or solar energy are considered as potential sources for a CIES. In fact, because thermal storage can play a major role in achieving a balance between demand and heat availability, it can have a major impact on the design and operation of the CIES distribution system as well as the CIES production system.[20]

2.6 Distribution

The distribution system that carries thermal energy from the production unit(s), in the form of steam or hot water, to the customer is the single most expensive capital item in a district energy system. The distribution system can account for over 50 percent of the total system cost, depending upon the length of the network, customer demand, the temperature at which the heat is transmitted, piping material selected, and the method of installation.[21]

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[20] Ibid., p. 36.

Heat transport costs, from source to consumer, are critical to the success of CIES as the choice of heat medium determines the maximum distance over which heat can be economically transported and which central sources may be potential heat suppliers to the system.

Although steam has a much higher heat content per pound than hot water, steam also requires substantially larger and more expensive transmission and distribution pipes. Steam systems also lose more heat, are not as safe, are more difficult to meter and are more difficult to operate for varying loads than hot water. In addition, if the transmission and distribution network is extensive, hot water is more easily transported than steam because it can be pumped, while steam can only be transported by pressure head.

The use of hot water as the transfer medium rather than steam requires lower plant equipment costs, reduces heat distribution losses, and provides a potential for heat storage. Finally, CHP is more efficient and cost effective when low or medium temperature hot water rather than steam is used, as the lower temperature allows a lower turbine back pressure and therefore a higher electrical output and generation efficiency. For steam distribution, the heat source must be within three to five miles of the service area. If hot water is used, the maximum distance is increased--25 km is a reasonable maximum distance for economical hot water transmission, although 45 km is reported for 350 MW of waste heat that will be transported from the town of Nynashamn to Stockholm, Sweden. Table 2.3 compares the general advantages and disadvantages of hot water and steam, clearly showing why modern district energy systems are based on hot water.

A recent study comparing District Energy St. Paul Inc.'s present hot water district energy system with the previous steam district energy system depicts the typical differences between modern hot water and the older steam distribution systems. During the ten year period over which the new hot water system has operated, there have been tremendous energy efficiency and environmental

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[21] Ibid.

TABLE 2.3

COMPARISON OF STEAM DISTRICT HEATING AND HOT WATER DISTRICT HEATING

System	Advantages	Disadvantages
Steam District Heating	Pumps not required	Piping range of 1 to 2 miles (1.6 to 3.2 km), 3 miles (4.8 km) maximum, for older systems; newer ones can achieve longer ranges with improved insulation.
	Can be a one pipe system with no return	
	Retrofit of old urban steam buildings may be easier	If steam is extracted from a cogenerator, a great deal of electricity is sacrificed.
		Steel pipes are required. They are expensive and they corrode.
		Water must be conditioned to prevent mineralization.
		If condensate is not returned (it usually is not), water, water conditioning, and low-grade energy are wasted.
		Use of high-temperature steam for space heat/service water heating is a poor energy and use match.
		High heat loss during distribution (15-45 percent).
		Piping, boiler, personnel codes are stringent; steam is not as safe as hot water.
		Installation is difficult--pitched piping, steam traps, pipe expansion, manholes.
		Maintenance costs are higher than for hot water systems
		Metering energy use is difficult.
		Very susceptible to mis-sizing or loss of large customers.
		Difficult to operate under conditions of varying loads.

(Continued On Next Page)

TABLE 2.3 (Continued)

System	Advantages	Disadvantages
Hot Water District Heating	Piping range of 15 miles (25 km), possibly up to 70 miles (110 km). Less cogenerator electricity sacrifice than for steam. Plastic pipes can be used--less expensive, no corrosion. Water need not be conditioned. Closed loop, so water is not wasted; nor is low-grade energy. Good energy end use match. Low heat loss during transmission and distribution (5-15 percent). Construction and operation codes easier to meet; relatively safe. Installation, retrofit to buildings generally easier than for steam. Lower maintenance costs than steam systems. Metering energy use is relatively easy. Not as susceptible to mis-sizing as steam systems are. Easy to operate under conditions of varying thermal load. Hot water can be stored.	Pumps are required. System balancing is important. System needs two pipes. Cannot provide high pressure steam if a customer on the circuit requires it--can act only as preheat.

SOURCE: District Heating and Cooling in the United States, *Strategic Planning and Energy Management*, Fall 1987, p. 63.

improvements. Overall system efficiency increased from 36 percent with the steam system to 75 percent for the hot water district energy system--virtually twice the useful energy is now supplied for the same fuel input. The energy efficiency of the distribution system increased from 64 percent for the steam system to 95 percent for the hot water system.

This dramatic increase was due to replacement of the aging steam lines with a new, well-insulated, closed-loop system of hot water pipes. District Energy customers have reduced their energy consumption by an average 20 percent by converting to hot water and upgrading their heating systems.[22]

Where steam is provided and is already an essential part of an industrial/commercial zone, it may be impractical to convert to hot water distribution. However, when new areas are developed (i.e., through urban renewal, rehabilitation or expansion), linking existing steam and new hot water systems may be appropriate. With this hybrid concept, steam is transmitted for the distance necessary to meet customer commitments, then is fed into a heat exchanger and pumping system for a hot water loop. As customers' requirements change and areas are renewed, the hot water service area can be developed back toward the heat source in a step-by-step fashion.[23]

In most hot water systems, the heat fluid is pumped through transmission piping to a distribution piping network and to customers through underground service piping. Distribution is accomplished by pumps that create a pressure differential between the supply and return lines. The amount of water that flows through each building is governed by a control valve that is sensitive to the demand for heat in the building. After heat extraction, the cooled fluid is returned through companion lines. Such systems require two pipes of similar size, unlike the single-pipe steam system. Since the water is returned to the boiler plant, the amount of fresh water and associated treatment that must be undertaken with hot water systems is greatly reduced compared to their steam counterparts.

At the customer's point of use, a heat exchanger (water-to-water or water-to-air) isolates the heat supply from the in-house system. Hot water may be produced from conventional steam electric generating plants by placing a heat exchanger in the path of the turbine exhaust to heat the system's water supply. This keeps boiler water separate from the water distributed for district energy, as well as materially reducing the cost of water treatment from the level experienced by steam systems where the condensate is not returned. Where existing buildings use hot water or forced air heating, the building retrofit is relatively simple, since only a heat exchanger and metering controls are required.[24]

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[22] District Energy St. Paul Inc., Annual Report 1990.

[23] International District Heating Association, *District Heating Handbook, Fourth Edition, Volume 1, A Design Guide* (Washington, D.C.: International District Heating Association, 1983), p. 16.

Hot water district energy systems can be subdivided into three groups based on peak temperature:

- low temperature--under 90°C
- medium temperature--90 to 120°C
- high temperature--over 120°C

Medium and low temperature systems have been built and operated in Europe for more than thirty years. Most systems being built or under study in Canada and the United States will use water at these temperatures because they combine a number of attractive characteristics not offered by other heat transfer fluids, including:

- high heat transport capacity;
- moderate thermal expansion requirements;
- sliding temperature operation to reduce heat losses;
- direct connection to building heating systems without life safety concerns (provided the maximum temperature is less than 100°C);
- provision of a heat sink for low grade heat recovery in conjunction with heat pumps; and
- the use of polyurethane insulation that facilitates a high performance, moderate cost, factory insulated pipe system.[25]

Modern hot water systems supply hot water at a temperature that varies according to the outside temperature. By reducing the water temperature, energy losses from the pipe system are reduced, and energy efficiency using low grade heat sources can be increased.

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[24] Ibid.

[25] Monenco Consultants Limited, DHM Energy Consults Ltd., K-Konsult, and Cogeneration Associates Limited, "Realistic Potential for District Heating in Canada, Volume I" April 1985.

Heat losses in modern, medium temperature, hot water distribution systems are about 5 to 10 percent annually.

In Sweden, water temperatures are normally between 70° and 120°C (160° to 250°F) in the supply pipe and between 30° and 65°C (85° to 150°F) in the return pipe. The lower temperatures refer to the summer season when the system is used exclusively for domestic hot water. Distribution efficiency increases with an increased temperature differential between supply and return. The thermal capacity of the system is determined by both the rate of water flow and the temperature differential. A large temperature differential allows the use of smaller pipes, which reduces the capital investment for construction of the system.

In principle, a lower temperature level in the CIES network means that average temperatures, and thus the pressure levels in the thermal condensers of the steam turbine, will be lower. More mechanical work can be extracted, enabling higher electricity production. For example, a reduction of the temperature by 10°C in both incoming and outgoing district energy water (i.e., from 55/85°C to 45/75°C) means that electricity production increases by approximately 4 to 5 percent. In addition, low return temperatures decrease the heat losses in the network and reduce the pumping costs, since a large temperature drop at the customer's end means that less water has to be circulated to fulfill customer requirements.

2.6.1 Chilled Water Systems

In chilled water district energy systems, water is reduced in temperature to just above freezing temperatures and distributed to customers who utilize heat exchangers for space conditioning. Chilled water can be produced either by use of an absorption refrigeration machine, electric-driven centrifugal chiller, gas or steam turbine-driven centrifugal chiller, or a combination of turbine driven mechanical systems and heat-driven absorption systems. Chilled water distribution is limited because large pipe systems are required and effective distances are less than in hot water systems.

There are numerous reasons for increased interest in district cooling. First, the capital invested in the heating plant, especially a cogeneration plant, can be used during the cooling season by providing steam for thermally driven chilling. Second, if the heating plant cogenerates and there is a need for peak electrical energy in the summer, cooling with thermal energy is virtually free, as the recovery of the exhaust steam produced from electricity generation can be used for cooling by means of absorption chillers. From a business perspective, customers are often more interested in district heating service if they can also purchase cooling service at the same time. If this can be achieved, a better load factor results.

District energy company labour is also used more productively with a cooling plant, since operators who service heating mechanical rooms in winter can be used to service cooling mechanical rooms in summer, as well as to run cooling plants. Fourth, the building owner's labour is often not reduced from central heat purchase alone, since the boiler operators are also responsible for the chilling plant. When the district energy company offers heating and chilling, it does not have a pro-rata increase in its labour, and the building served can eliminate trained operators.

The growing choice for new building Heating, Ventilation and Air Conditioning (HVAC) equipment is unitary heat pumps that both heat and cool. By offering cooling together with district heating, the district energy company solves the building owner's real problem, namely how to construct a new building without the capital cost and operating headaches of on-site heating and chiller plants. Finally, heat-based systems do not release chlorofluorocarbons (CFC's) into the atmosphere to destroy ozone and contribute to the greenhouse effect.[26]

2.6.2 Technology Developments

Distribution technologies for steam and hot water are well established but development work continues to improve the cost effectiveness of hot and chilled water systems. In particular, friction reducing additives show promise for reducing pump pressures, pipe sizes and pumping costs. For chilled water systems, several ice slurry technologies are being explored. If laboratory results prove out, a greater cooling capacity for a given pipe size will be possible, thereby reducing investment costs in the distribution network. Canada has developed a major capability in novel district cooling technology and is supplying ice slurry chillers to Japan.

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[26] Thomas R. Casten, Trigen Energy Corporation, "To Cool or Not to Cool: Making the Move from DH to DHC," *District Heating and Cooling*, Vol. 74, No. 3, First Quarter, 1989.

2.7 Building Sub-stations

The interface between the district energy distribution system and the building heating and cooling system takes place at the sub-station located in the building's basement. Sub-stations typically consist of (1) heat exchangers to transfer thermal energy from the piping network to the building's system; and (2) metres to measure the amount of thermal energy transferred from the district energy system to the building. In some cases, called direct systems, no heat exchangers are used. In Germany, for example, building heat systems are designed for the temperature and pressure of the hot water distributed in the network. Another example would be district cooling systems where the chilled water is pumped directly through the building. Figure 2.8 brings together schematically all the components of a district energy system.

The direct system is limited to uses where water is the distribution medium and where the water quality and pressure requirements are the same for the heat source and the distribution system. Indirect connection allows the heat sources and distribution system to be operated as separate systems with different temperatures and pressures, allowing more design flexibility for both systems. By and large, indirect systems are the preferred method of customer connection.

2.7.1 Technology Developments

Technical advances have occurred in the efficiency of steam-based chilling systems that can utilize district energy steam. Also, attention is being placed on improving the cost effectiveness of building metering equipment.

2.8 District Energy Applications

While the prerequisites for district energy vary, it is preferred, though not necessary, that existing buildings already have a hot water or steam heating system and that the heat requirement per unit of city area (heat density) be relatively high.

High heat density is needed because the distribution network that transports hot water to the buildings is expensive. The heating density can be increased by adding water heating, cooling, and industrial loads to the basic space heating requirements. This permits more energy to share the expense of the distribution system.

Several factors determine if district energy could be economic:

Areas should have high thermal load densities. Thermal load density is crucial because it is the major determinant of thermal distribution capital and operating costs. Local distribution system costs, encompassing the piping running from transmission lines to individual service lines, are the largest single component (over 50 percent) of capital costs for a district energy system using retrofitted existing power plants. In an urban area, the central business district is often the location with the highest thermal load density.

Connected loads should have a high load factor. The load factor is the ratio between the actual amount of energy consumed annually to the amount of energy that would be consumed if the peak thermal load were to be imposed continuously for a full year. A high load factor maximizes utilization of thermal energy production and transport equipment. An area that has both a high thermal load density and a high load factor naturally will have a high density of annual thermal use. Such areas are attractive opportunities for community integrated energy systems, since distribution costs are comparatively low and costs can be quickly recovered from high energy sales.

Market areas should be as close as possible to thermal sources. Close proximity of thermal loads and sources reduces capital costs, operation and maintenance expenses and heat losses. Transmission line costs usually comprise about 20-30 percent of all capital costs.

New development or redevelopment areas often are useful in forming the core of the initial district energy service area.

Groups of buildings under single ownership should be included whenever possible. Examples include university campuses, hospitals and military complexes. Such customers can be important in building up the initial "threshold" load, below which system implementation is not practical.[27]

Generally speaking, district energy is best suited to those areas that have a high building and population density, situated in relatively cold climatic zones. Because the central business district (CBD) usually contains the largest number of contiguous energy-intensive zones, it is an obvious area for district energy service. It is more economic to connect large buildings to a district energy system, since more energy can be delivered with lower connection costs. In addition, many large buildings have boilers that can be used for backup to a district energy loop or that could reduce the district energy peak heating load, since they could use their own on-site boilers during peak conditions. District energy is thus suitable for densely populated areas--apartment complexes, hospitals, office buildings, factories, schools and university and military facilities. However, a sufficiently large, intensive load other than the CBD might also be located near a thermal source--e.g., locating greenhouses to use thermal heat generated at nuclear power facilities.

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[27] International District Heating Association, *District Heating Handbook, Fourth Edition, Volume 1, A Design Guide*, p. 24.

2.8.1 Heating Markets

District energy systems can be classified according to the type of area or market they serve:

- densely populated urban areas
- high density building clusters
- industrial complexes
- low density residential areas.

Studies of existing systems have shown that district energy can be economically productive in the first three markets listed above. European experience indicates that single family residential areas may also be economically served (see Part II for a review of European experience with CIES).

2.8.1.1 Densely Populated Urban Areas

In the central core of densely populated metropolitan areas, CIES systems should be multi-purpose in order to serve as large a number of consumers as possible. A twenty to thirty year phased construction period would not be unlikely for such a system. Massive amounts of financing would be required for the many kilometres of distribution pipes and generation of the megawatts of thermal capacity needed.

In contrast, a system for a smaller city core area would require only a few hundred megawatt capacity and a few kilometres of distribution piping. Construction could range from only a few years up to about ten years, with capital requirements running in the tens of millions of dollars. Some characteristics would be common to systems in both areas:

- a variety of building types and energy uses will be included;
- thermal energy sources probably will be surplus heat from electric and industrial plants, and urban waste disposal facilities;
- distribution network costs will comprise a majority of the system costs; and
- institutional arrangements for achieving a successful system will be extensive and complex, involving both public and private sectors.

2.8.1.2 High Density Clusters

High density developments include shopping centers, universities, high-rise residential complexes, or a high-density mixed suburban development. Characteristics of the system include:

- Both plants and distribution network will probably be new and designed specifically for the application.
- The distribution network may be relatively small, comprising a small part of total system cost.
- Coal-fired systems may be used for larger systems, with gas used in smaller applications.
- Central source may be a new cogeneration plant or a facility making use of surplus heat from an existing industrial or electric plant.
- Institutional arrangements are usually simple, involving only a few decision-makers.

Financing would be from a few million to tens of millions of dollars and construction would run from a few years to ten years in one or two phases.[28]

2.8.1.3 Industrial Complexes

Special demands of systems for industrial complexes determine both the type of system and its economics. Steam, hot water, or both may be necessary and industrial process loads will dominate system use. Central plant technology and fuels will be similar to those for high density clusters. Institutional arrangements should be simple, but varied thermal requirements may make distribution systems complex. A high utilization factor generally makes for favourable economics.

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[28] Ibid., p. 9.

2.8.1.4 Low Density Residential Areas

A district energy system for low density residential developments typically would serve an area dominated by single or duplex residential units. Such systems would probably have the following in common:

- Cost of the distribution system, most likely low temperature hot water, would dominate construction costs.
- Water-source heat pumps could augment system capacity.
- Central source is likely to be new, with capacities of less than 1 MW to a few MWs.
- Institutional arrangements may be moderately complex.
- High capital costs and low utilization make this type of system marginally economic in most areas.

2.9 Construction

Community integrated energy systems are commonly built in stages, often using provisional generation facilities prior to the construction of permanent plants, that may serve as a cluster of district heating islands. These islands are later connected in a unified network. Construction in stages typically allows better planning for the overall system and reduces demands on personnel and financial resources.

2.10 Piping

Experience has shown that distribution piping can be 50 percent or more of the total installed cost of a district heating system, so careful attention to installation is very important.

Most modern district energy systems use prefabricated piping, consisting of an inner transport pipe of steel, an insulating layer of polyurethane foam, and a protective sheath of strong polyethylene. The insulation is applied in the factory so that a permanent bond is formed between the transport pipe and the protective sheath, contributing to minimal heat losses and maintenance free service for a large number of years. The leak detection system can also be built into the insulating layer.

The upper temperature limit is usually 120°C, which is at present the limit that can be withstood by the insulation without its permanence and heat insulating capabilities being altered to an unacceptable degree with time. Plastic encased piping is laid directly in a trench, with a drainage and protective filling of coarse gravel and sand. The pipe laying depth is chosen to avoid unacceptable forces from traffic loads. Piping in concrete channels, at one time the most widely used form of construction, is now seldom used. This is because the prefabricated piping with polyethylene casing is cheaper and easier to handle.[29] A new type of Swedish piping incorporates the supply and return pipes in the same casing. This piping offers a number of technical and economic advantages--the heat loss is lower than in conventional piping; fewer couplings, elbows and tees are required; and the piping is easier to install.

Pipe prices have fallen considerably due to better processes for pipe production, for welding of pipes in the field, and for burying pipes. Falling pipe prices means that it is possible to extend the district energy system further than was previously possible.[30]

2.11 Metering Equipment

District energy metering systems for the purpose of billing customers can be based on the quantity of water used (volume metering), quantity of heat used (energy metering), quantity of water used times the supply temperature, or specified apportionment factors (non-metre billing). Water volume meters measure water flow through a counter that registers the passing volume of water. Meters cost little to purchase and operate. The objection to volume metering is that it does not rationalize the consumer's use of energy. To encourage the most rational and economic use of energy, heat meters that measure the difference in temperature between incoming and outgoing hot water as well as the volume of water passed through as the basis for customer charges are commonly used in modern district energy systems.

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[29] The Swedish District Heating Association and the Swedish Trade Council, *District Heating, Clean Heat for Urban Areas* (Sweden: The Swedish District Heating Association and the Swedish Trade Council); and National Energy Administration, *District Heating, Temperature Levels in District and Local Heating Systems in Sweden*, 1987:R4 (Sweden: National Energy Administration, 1989)

[30] Vanglund G. Lund-Jensen, "Cogeneration and District Heating," *proceedings of the Euroforum - New Energies Congress, Volume 1, Saarbrucken, Germany, October 24-28, 1988.*

Experience in a number of countries shows that the consumption of energy and domestic hot water can be reduced by 30 to 50 percent through the use of individual metering--an argument strongly supporting the practice of individual rather than collective recording of heat consumption.[31]

2.12 Economics

In common with other energy forms such as natural gas and electricity, district energy is highly capital intensive. In fact, a majority of the capital investment required for a CIES goes into the facilities needed for transmission and distribution. While low-cost non-metallic piping, improved installation techniques, and low cost metering continue to improve the market outlook, district energy systems require a large and stable cash flow and consequently a large heat-load density to support the system's high capital costs. Both the heating plants and distribution network are **significantly** affected by economies of scale, with the result that the delivered cost of heat tends to decrease with increasing heat loads and heat densities.[32]

Larger office and apartment buildings will increase both heat density and heat loads as well as reduce connection density. These factors will tend to reduce the unit cost of energy delivered and consequently a larger city will likely have more potential for district energy than a smaller one.

A district energy system must connect the maximum number of users in a service area to the system as soon as practical, as the rate of consumer connections sets the pace for revenue, which in turn determines the economic success of the system. **However, once the system is in operation and the initial consumer connection rate is satisfactory, the cost of connecting new buildings into the system is often less than the cost of furnace or boiler installations**. Cost of conversion for existing buildings depends on multiple factors, such as age, type and condition of existing equipment, since conversion to district energy becomes more attractive when existing systems are in need of replacement.[33]

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[31] The Swedish District Heating Association and the Swedish Trade Council, *District Heating, Clean Heat for Urban Areas* (Sweden: The Swedish District Heating Association and the Swedish Trade Council).

[32] Monenco Consultants Limited, DHM Energy Consults Ltd., K-Konsult, and Cogeneration Associates Limited, "Realistic Potential for District Heating in Canada, Volume I", p. 16-17.

The investment for subscriber heating equipment is an important part of the total cost of a district energy system. Retrofit costs to convert a building are **significantly** affected by the type of existing heating system (forced air, hot water or hydronic, electric baseboard). For example, a building with electric baseboard heating will require a complete replacement of its existing heating system to accept district energy, while a building with a forced air or hot water system can continue to use existing ducting or piping when retrofitted to CIES. Newfoundland, New Brunswick and Quebec have a high percentage of electric baseboard heating, making them unlikely candidates for CIES applications in existing structures.

Community integrated energy systems depend on several site-related factors such as the availability and price of alternative energy sources, market potential, peak hourly loads, annual energy use patterns, and the potential for cogeneration. The choice of a piping system depends on the space heating and cooling requirements, the service hot water requirements and the transport media (chilled water, hot water or steam). Typically, production plants should be located as close to the district energy service area as possible, as this reduces system energy losses and the cost of the thermal transmission system. Evaluation of **all** of these site-specific factors is required to determine the economic feasibility of a new district heating system or the retrofit or expansion of an existing system.

Without access to all of this site-specific information, one cannot evaluate the potential market penetration for this technology in Canada and the impact, other than in a generic sense, that district energy could have on SO_2, NO_x and CO_2 emissions reduction.

Chapter 4 discusses some of the major barriers that presently stand in the way of greater CIES implementation in Canada.

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[33] International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *Guidelines for Converting Building Heating Systems for Hot Water District Heating*, 1990 R3, NOVEM.

Chapter 3

BENEFITS OF DISTRICT ENERGY

3.1 Overview

District energy systems offer many benefits to building owners and tenants, the local community and society in general. Some of the most important benefits are:

3.1.1 Energy Utilization and Management

District energy systems can use combined heat and power plants, to produce energy more efficiently. Community integrated energy systems (CIES) can also incorporate several different energy sources thereby reducing the dependency on the supply of any single source, such as oil or natural gas.

3.1.2 Operations Management

District energy systems simplify the operations management of buildings by eliminating the requirement for on-site boiler operation and maintenance. Therefore, reliability of thermal energy supply is increased with district energy systems.[1]

3.1.3 Economic Attractiveness

Community integrated energy systems generate significant employment during construction and, when locally available energy sources are used, keep energy expenditures in the local community. Building owners avoid capital expenditures for installation of on-site systems and save labour costs for boiler operation and management.

3.1.4 Environmental Enhancement

Compared to individual, on-site building systems, CIES produce fewer emissions to heat and cool the same number of buildings and are easier to monitor and control. Community integrated energy system networks increase options for the utilization of waste energy sources and facilitate the phaseout of chlorofluorocarbons (CFCs).

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[1] International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *District Energy Systems, Promotional Manual for System Developers and Operators*, November 1991.

3.1.5 Community Impacts

Economic impacts of district energy systems can range from economic revitalization projects to a major incentive for industrial growth.

District heating can often be a catalyst for, or an adjunct to, urban or neighborhood renewal projects. It can also provide economic incentives to existing or new industries that are able to increase revenues by selling waste heat to the CIES and at the same time reduce the cost associated with waste heat disposal. In the Swedish town of Landskrona, nearly 3000 jobs were lost in the early 1980s when a major shipyard went out of business; however, the city used the construction of a new CIES to attract several new industries, adding over 1500 new jobs to the community. The ability to sell waste heat to the CIES system has also stabilized the economies of several existing industries.[2]

Employment benefits from CIES include not only temporary and permanent jobs created from system construction and operation and from industrial growth, but also from retrofitting building systems to be compatible with the CIES system. On a broader scale, employment opportunities will also be created in the industries that supply equipment used to construct district energy systems. Such employment would be primarily in the steel, pipe, and boiler manufacturing products sectors. Whether CIES will result in a net increase in employment in the urban region or simply a shift of employment from, for example, equipment manufacturers to pipe manufacturers depends on the particular characteristics of the urban community and the CIES network.

3.1.6 Investment Impacts

District energy systems result in investment in local communities and substantial tax revenues.

3.1.7 New Investment Opportunities

The introduction of CIES to Canada opens up an important new multimillion dollar market opportunity crossing many disciplines and industries. Manufacturers, consulting firms, municipalities, and gas and electric utilities are a few of the parties that could benefit from greater CIES development.

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[2] City of Toronto, "The Changing Atmosphere: Strategies for Reducing CO_2 Emissions, Technical Volume," Special Advisory Committee on the Environment, Report No. 2, Vol. 2, Toronto, Ontario, March 1991, p. 7.

Table 3.1 provides a summary of the most important features and benefits of CIES. It is important to realize, however, that the potential benefits of district energy systems are not of equal importance to the three main constituencies--building owners, municipalities and society in general.[3]

Building owners, for example, stress financial and operational considerations. Municipalities, in contrast, focus on the public as well as private interests of their community. Community economic development and environmental enhancement, for example, are areas of primary concern for municipal officials but are of lesser interest to building owners. The interests of society, reflected in the actions of national and provincial governments and international organizations, are similar to those of a municipality. For the governments, policy concerns related to energy efficiency and security, and long-term economic and environmental well-being are paramount.

For district energy to become a serious alternative to existing or future on-site heating systems, it must provide significant benefits to both the community and consumers who purchase energy from the system. In addition, it must provide net societal benefits if government is to commit to actions that will foster CIES development.

3.2 Benefits to Society

If society is to endorse CIES it must be convinced that district energy will provide an overall net socio-economic benefit in comparison to other heat and electricity supply options. Such a determination must be based on a thorough evaluation--including energy, environmental, economic, and employment impacts.

A principal environmental benefit of district energy is its ability to use what would otherwise be waste products. These may include biomass (i.e., waste from the forest products industry and straw), garbage, industrial waste heat, and sewage effluent. All of these waste products can have serious environmental impacts if not properly handled.[4] The use of biomass to fuel a district energy system can significantly reduce the need for slash and field burning.

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[3] Ibid., p. 7.

[4] Gordon R. Bloomquist, John T. Nimmons and Kevin Rafferty, *District Heating Development Guide, Legal, Institutional, and Marketing Issues, Volume I* (Olympia, Washington: Washington State Energy Office, October 1988).

TABLE 3.1

MAJOR BENEFITS OF DISTRICT ENERGY SYSTEMS

Type of Benefit	Building Owners	Municipalities	Society
Energy Utilization and Management	- Assure access to lowest cost energy sources	- Utilize available energy sources within the community	- Increase efficient use of energy - Increase energy security through diversity of supply
Operations Management	- Increased reliability of supply of thermal energy - Eliminate on-site boiler operation and maintenance		
Economic Attractiveness	- Eliminate capital for on-site energy system - Reduce labour and maintenance expenses for on-site system - Make space available for income or other purposes	- Significant employment during construction - Enhanced viability of downtown core - Local energy sources keep energy expenditures in the community	
Environmental Enhancement	- Avoid future more stringent regulations of stacks, etc. - District cooling or steam absorption systems may provide options to management of CFC replacement	- Greater efficiency reduces total emissions - Single tall stack disperses emissions from metro area - Single stack easier to monitor and implement controls - Utilization of waste energy sources helps waste management	- Greater efficiency reduces total emissions - Single stack easier to monitor and implement controls Utilization of waste energy sources helps waste management - District cooling or steam absorption systems may provide options to management of CFC replacement

SOURCE: International Energy Agency, *District Energy Systems, Promotional Manual for System Developers and Operators*, Second Draft, November 1991.

The ability to use the heat produced from garbage incineration can greatly reduce the overall cost of incineration and help ensure that CIES plants can be operated at optimum levels, so that groundwater and soil pollution are not simply traded for an increase in air pollution.

Another major source of waste heat is sewage effluent. Water heated in homes, businesses, and industries passes through local sewage treatment plants and exits at 16 to 27°C (60 to 80°F). Large heat pumps could easily use that heat for a district energy system. For example, one such plant in Solna, Sweden, uses four 30 MW heat pumps to provide 120 MW for the local district energy system, while at the same time reducing the water temperature to a more acceptable level before releasing it to the environment.[5]

3.2.1 Environment

Conventional power stations designed strictly for electricity production use only about 35 percent of the energy content of the fuel they burn. The other 65 percent is lost in flue gases and condenser cooling. This waste energy is then discharged to the atmosphere or surface water. Community integrated energy systems are uniquely suited to harness the spin-off energy of combined heat and power (CHP), the simultaneous generation of heat and electricity, because it efficiently captures and distributes the heat that would otherwise be wasted during electricity generation.

Using a community's rejected energy resources in CIES helps displace fossil fuels that might separately have to be used to produce electricity, space, or process heating and cooling. Cogeneration of heating, power and cooling are well proven technologies that have been applied in many places. Combined heat and power gives a major improvement in energy efficiency. This means that considerably less fuel is consumed, resulting in a reduction in waste emissions of all forms.

European cities that extensively employ CIES have very low levels of locally generated air pollution. For example, Stockholm, Sweden reduced its SO_2 emissions by 95 percent in 25 years, due in part to the extensive development of CIES.[6] The Danish experience clearly shows that CHP offers an opportunity to achieve significant improvements in energy efficiency while simultaneously reducing the CO_2 emissions resulting from increased use of coal. Estimates for Denmark show that a reliance on coal-fired CHP plants will reduce CO_2 emissions relative to coal use in heat-only district heating plants by about 19 percent. In Denmark, energy consumption for space heating is approximately 30 percent lower than levels prior to the oil crises in the 1970s--a considerable amount of this reduction being achieved through CHP.

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[5] Ibid., p. 6.

Table 3.2 presents a summary of the various CO_2 abatement measures for coal use in power generation.[7] As indicated, coal technologies such as advanced Pulverized Coal (PC) boilers and Atmospheric Fluidized Bed Combustion (AFBC) can achieve reductions in CO_2 emissions of 9 to 31 percent as compared with the existing average of thermal power plants. Pressurized Fluidized Bed Combustion (PFBC) and Integrated Gasification Combined Cycle (IGCC) are expected to be in wide-scale commercial use shortly. These technologies offer the potential for reducing CO_2 emissions from 16 to 45 percent versus existing coal-fired power plants. Longer-term, IGCC/fuel cells and magnetohydrodynamics (MHD) offer the potential for reducing CO_2 emissions by more than half compared to existing coal-fired power plants.

Most importantly, as noted in Table 3.2, the estimated reduction in CO_2 emissions for CHP plants is 59-69 percent. This clearly indicates that CIES using conventional technology surpasses any imminent or developing technology.

District energy not only ensures fewer emissions per useful unit of energy output, but the potential to install emission control equipment is both greater and cheaper per unit of energy produced. Because a CIES can supply heat and cooling to several buildings, or to entire complexes or neighborhoods, it can eliminate the uncontrolled emissions and intrinsic inefficiency of individual, on-site energy systems. The relatively large scale of most district energy systems allows them to use state-of-the-art pollution-control devices and technology that small, stationary on-site building systems cannot. The fact that district energy plants are operated by trained personnel contributes further to the economic and efficient operation of CIES generation plants and reduced environmental impacts.

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[6] International District Heating and Cooling Association, "IDHCA, Comments on the National Energy Strategy," *District Heating and Cooling*, Vol. 76, No. 1.

[7] Irene M. Smith and Kelly V. Thambimuthu, *Greenhouse gas abatement and control: the role of coal*, IEACR/39 (London, England: IEA Coal Research, June 1991), p. 49.

TABLE 3.2

COMPARISON OF ENERGY EFFICIENCY[a] AND THE CO$_2$ REDUCTION POTENTIAL FOR VARIOUS COAL-FIRED POWER GENERATION TECHNOLOGIES

(percent)

Base Case	Energy Efficiency[b] Average Low	Energy Efficiency[b] Average High
Existing Thermal Power Plants	25	33

	Energy Efficiency	Potential Reduction in CO$_2$ Emission from Base From Low Base	Potential Reduction in CO$_2$ Emission from Base From High Base
Commercially Advanced			
Pulverized Coal (PC)	37	31	9
Atmospheric Fluidized Bed Combustion (AFBC)	37	31	9
Co-generation			
Combined Heat and Power (CHP)	81	69	59[c]
Imminent			
Pressurized Fluidized Bed Combustion (PFBC)	40	36	16
Integrated Gasification Combined Cycle (IGCC)	42	39	20
Hybrid IGCC/FBC	46	45	27
Developing			
IGCC/Fuel Cells	50	49	33
Magnetohydrodynamics (MHD)	55	55	40

SOURCES: (1) International Energy Agency, *Potential to Reduce Carbon Dioxide Emissions*, Technical Report (Paris, France: IEA, 1991), p. 33; (2) Irene M. Smith and Kelly V. Thambimuthu, *Greenhouse Gases, Abatement and Control: The Role of Coal* (London, U.K.: IEA Coal Research, June 1991); and (3) Canadian Energy Research Institute.

[a] Energy efficiencies are stated on a net basis. Energy efficiencies for commercially advanced, imminent, and developing technologies are mid-range estimates that may vary by 1-2 percent for the figures shown.

[b] Higher figure representative of the current average level of thermal power plant efficiency in the more developed countries. The lower figure is representative of the average level of thermal power plant efficiency in many less developed countries.

[c] CO$_2$ reduction figure for the direct replacement of PC plant without low grade heat recovery. CO$_2$ reduction of 34-39 percent when replacing existing and separate coal-fired power and district heating plants.

For example, Trigen Energy Corporation, an international developer and operator of cogenerated district energy facilities in the U.S. and Canada, has seen reductions in fuel consumption of 40 to 50 percent versus conventional central electric plants and on-site thermal boilers.

3.2.2 Cooling

In addition to reducing acid rain and CO_2 emissions, CIES can help to reduce ozone depletion by displacing the use of ozone depleting chlorofluorocarbons (CFCs) in existing air conditioning units.

Chlorofluorocarbons are man-made chemicals containing chlorine, fluorine and carbon, that exist as gases or liquids. Chlorofluorocarbons have two major effects on the environment: (1) greenhouse effect--CFCs act as greenhouse gases (considered major contributors to the greenhouse effect); and (2) stratospheric ozone-depletion effect--CFCs are not destroyed in the lower atmosphere but waft slowly upward toward the stratosphere where they eventually break down. Each of the atoms released in the break down is capable of destroying tens of thousands of ozone molecules, thus contributing to the thinning of the protective stratospheric ozone layer. In the stratosphere (at altitudes of 15 to 35 km) the ozone layer acts as a natural filter absorbing most of the sun's damaging ultraviolet rays--rays that burn the skin and cause some forms of skin cancer.[8]

Increased interest in **district energy for cooling** is occurring because:

- The greenhouse effect could increase average global temperatures and increase the market for chilling.
- Energy use in commercial buildings has grown faster than in any other end use sector during the last twenty years. The fastest growing use has been for air conditioning, thereby exacerbating peaks in electric loads and creating pressure for new power plants. Community integrated cooling systems can directly substitute for electric air conditioning, cited as a key driver of increases in the electric peak and resulting need for new power plants.
- Commercial sector conservation expenditures require short horizon paybacks to building owners. For new buildings or buildings undergoing renovation, district energy offers a way for building owners to reduce capital costs because the boiler, chiller and ancillary equipment are not needed.

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[8] Alberta Energy and Alberta Environment, "Clean Air Strategy for Alberta, Framework Document," Draft for discussion, Edmonton, Alberta, August 1991, p. 14.

Thus CIES fits well with building owners' desires to minimize capital costs.

- Using district energy waste heat to provide cooling during the summer months can dramatically improve overall CIES economics.[9]

District cooling plants can use large, high-efficiency (double or triple stage) absorption cooling systems. Central district cooling plants can adapt to ammonia, an effective, low-cost refrigerant that is widely used in industrial applications. Ammonia released to the atmosphere at controlled rates is not environmentally harmful and does not contribute to ozone depletion and global warming. However, since building codes constrain the use of ammonia in buildings due to toxicity concerns, central plant district cooling is the best way to bring this important technology to bear immediately on facilitating the phasing out of CFCs.

Because district energy can take advantage of ammonia chilling methods on a scale not available in individual building cooling systems, it can help lower electrical utility summer peak loads by displacing electrically-driven building chillers or air conditioners. Once established, a district energy system has the flexibility to be connected to other efficient heating and cooling sources (i.e., industrial waste heat or cool water from lakes, rivers or ground water) to become a fully integrated community energy system.

In general, the advantages of district cooling are:

Economic Issues

- Eliminates capital cost of on-site cooling equipment.
- Increases leasable building space.
- Reduces construction costs of supports and piping.
- Eliminates need for make-up water treatment and additional water service size.
- Eliminates need for additional electric service for cooling tower fans.
- Reduces operating and maintenance costs.
- Eliminates need for installing standby equipment.

Non-Economic Issues

- Eliminates potential for negative aesthetic impact of mechanical equipment and cooling towers on building exterior.
- Provides for greater construction flexibility.

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[9] International District Heating and Cooling Association, "IDHCA, Comments on the National Energy Strategy."

- Reduces need for additional replacement capital and accompanying financial risk.
- Reduces operational risks.
- Shortens time frame for return on investment.

3.2.3 Fuel Flexibility

As the distribution of energy in a CIES is made through hot water or steam, different energy sources can be optimally combined according to price and fuel availability. Coal, industrial waste heat, large heat pumps and waste heat from nuclear power plants are all suitable. Renewable energy such as waste wood, municipal solid waste, geothermal energy, seasonal thermal storage, cold ocean, lake or river water or other sources, can be tapped more economically than on an individual-building scale.

Moreover, the use of biomass fuels to replace fossil fuels results in a decrease in carbon dioxide emissions. Wood fuel burning, combined with sustainable yield forestry practices, can have a neutral CO_2 impact since carbon dioxide fixed in growing trees can be released through combustion at the same rate.[10] Use of indigenous community resources such as biomass also results in important community economic benefits. For example, in Charlottetown, P.E.I., wood chips burned for the city's CIES support a local wood fuel industry. Rather than spending money on out-of-province fossil fuels, a local industry is supported--keeping money and employment in the local economy.

The capability to switch to different fuels in response to energy prices and fuel availability would add greater flexibility to Canada's energy system and would decrease dependence on foreign markets for energy supplies. In Sweden for example, fuel oil, coal, peat, woodchips, refuse, waste heat, natural gas, electrical boilers and heat pumps are all used for community district energy.

3.2.4 Integrated Resource Planning (IRP)

District energy systems fit well with the growing trend to integrated resource planning because district energy facilitates planning for energy services in a context that is broader than simply planning for electricity or gas supply and distribution (see Table 3.3).

Properly structured, the combined result of demand-side management (DSM) and IRP programs for electric

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[10] Michael J. Wiggin, Energy, Mines and Resources Canada, "District Heating In Canada: Where We Are and Where We Are Going," *District Heating & Cooling*, Vol. 75, No. 3, First Quarter 1990.

TABLE 3.3

DIFFERENCES BETWEEN TRADITIONAL PLANNING AND INTEGRATED RESOURCE PLANNING

Traditional Planning	Integrated Resource Planning
Focus on utility-owned central-station station power plants	Diversity of resources, including utility-owned plants, purchases from other organizations, conservation and load-management programs, transmission and distribution improvements, and pricing
Planning internal to utility, primarily in system planning and financial planning departments	Planning spread among several departments within utility and often involves customers, public utility commission staff, and non-utility energy experts
All resources owned by utility	Some resources owned by other utilities, by small power producers, by independent power producers, and by customers
Resources selected primarily to minimize electricity prices and maintain system reliability	Diverse resource-selection criteria, including electricity prices, revenue requirements, energy-service costs, utility financial condition, risk reduction, fuel and technology diversity, environmental quality, and economic development

SOURCE: Eric Hirst and Charles Goldman, *Heating the Future: Integrated Resource Planning for Electric Utilities Annual Review of Energy and the Environment, 1991,* 16:91-121 (Palo Alto, California: Annual Review Inc., 1991).

> **and gas utilities will be the appropriate use of different fuel types for various applications. As the consumer considers the comparative advantages of the fuels within the framework of a competitive marketplace, the optimum outcome should be ensured.**[11]

Many utilities argue that it is inappropriate for Public Utility Boards (PUBS) (i.e., the Ontario Energy Board) to place significant additional costs that result from environmental externalities only on electric utility consumers, and not on consumers of other fuels. Thus, electric utilities and others are likely to raise questions about the role of PUBs in addressing environmental externalities versus the roles of federal and provincial government agencies directly responsible for environmental quality (e.g., the Ontario Ministry of the Environment and Environment Canada).[12]

Increased attention to environmental concerns may provide an important impetus for public policy-makers and PUBs to broaden the boundaries of IRP. For example, PUBs may ask gas and electric utilities to compare the social costs and benefits of providing energy services (e.g., water heating or cooking) using gas directly versus gas-fired electric generation. Public policy concerns about the environmental impacts of energy technologies may result in significant changes in the demands for electricity and gas. For example, the policies of local air quality boards that limit vehicle emissions (and, for example, encourage electric cars) or national legislation affecting greenhouse gas emissions could affect future electricity and gas uses.[13]

By improving the energy efficiency of existing electric power stations and broadening the planning for new facilities to meet growing electrical and heating demands, CIES can eliminate many large power plant disadvantages:

- high investment and overhead expenses;
- long transmission lines to convey electrical power to the actual users;
- need for transformers to step-up and step-down voltages; and

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[11] Canadian Gas Association, Natural Gas and the Environment, submission to the House of Commons Standing Committee on Energy, Mines and Resources (Don Mills, Ontario, September 1991).

[12] Eric Hirst and Charles Goldman, *Heating the Future: Integrated Resource Planning for Electric Utilities Annual Review of Energy and the Environment, 1991,* 16:91-121 (Palo Alto, California: Annual Review Inc., 1991), p. 103.

[13] Ibid.

- large electrical losses incurred in transforming and transmission operations.[14]

Other benefits of combining CHP with CIES for electric utilities include:

- CO_2 emissions from the production of electricity from fossil-fired plants can be substantially reduced at low technology risk.
- electrical energy can be stored in the form of usable thermal energy.
- electrical peak load demand can be substantially reduced as waste heat can be used for space heat or cooling and thereby displace electricity production.
- electrical generation growth and site selection are integrated into a community's energy plan.

Moreover, increased CHP/CIES activity could:

- delay or cancel large expensive generating plants.
- allow the utility system's excess capacity to be safely reduced.
- offer better load control where utilities use cogenerated power to lower their peak demand.
- increase the flexibility of the entire utility system and help to respond to unexpected demand changes and system failures.[15]

3.2.5 Expanding Options for New Electrical Capacity

Some of Canada's large, provincially-owned electric utilities are very concerned about their ability to meet future electrical needs due to the long lead times required for the construction of new generating plants, nuclear moratoriums, and the advent of stricter pollution controls. In Ontario, for example, the Ontario Government has declared a moratorium on new nuclear generating stations and has directed Ontario Hydro to accelerate efforts on demand-side management, energy conservation, and parallel power generation, arguing that greater energy efficiency will mean a cleaner environment and more secure jobs. Buying surplus electricity from parallel generators (such as district energy systems) could be one way of alleviating electricity capacity concerns and a policy supplement to utility demand-side management programs.

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[14] Southern Alberta Institute of Technology, Power Engineering Department, "Cogeneration Assessment Study, Third Phase Report," prepared for Alberta/Canada Energy Resources Research Fund, July 1989.

[15] Southern Alberta Institute of Technology, Power Engineering Department, "Cogeneration Assessment Study," prepared for Alberta/Canada Energy Resources Research Fund, September 1986.

By selling surplus electricity to Canada's large electric utilities, new district energy systems can help reduce the number of new power plants required. Alternatively, if district energy retrofit systems are built, they could help make existing power plants far more energy efficient through cogeneration. Moreover, the two production systems are a natural fit because district energy systems have thermal peaks in winter, when electric utilities can afford the slight derating involved in extracting thermal energy, and can employ excess capacity in summer to drive thermal chilling to reduce electrical peaks.[16]

New high efficiency CHP and CIES technologies attack the improvement of energy efficiency primarily from the supply side rather than from the demand side. Greater energy efficiency can be achieved faster through CHP and CIES technologies than would be possible by focusing on demand-side management alone. Moreover, as many Canadian electric utilities are only now seriously investigating the role and impact of DSM (gas utilities to even a lesser degree), CHP-based district energy systems may provide the capacity needed for those regions in Canada that will soon need new electrical generating capacity.

Other arguments supporting increased electric and gas utility interest in CIES systems are:

- the existing base for district energy retrofits is already in place, in close proximity to high-density thermal loads;
- many systems would use gas turbine cogeneration; and
- unlike some DSM programs, the cost and effectiveness of district energy are easily quantifiable, given site-specific energy use characteristics.

3.2.6 Promoting New Technologies

Due to economies of scale, CIES can cost-effectively implement sophisticated pollution-control systems and advanced combustion technologies. Clean coal technologies (CCT) are being developed rapidly, but their full potential may not be realized unless large heat loads can be assembled, as these new technologies are more economic at large capacities.

District energy technology could be instrumental in realizing the use of indigenous resources and furthering the commercial development of CCT technologies such as Integrated Gasification Combined Cycle and

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[16] International District Heating and Cooling Association, "IDHCA, Comments on the National Energy Strategy."

Pressurized Fluidized Bed Combustion.[17] The application of these technologies could be of considerable assistance in furthering Canadian development and, in addition, would foster the sale of Canadian technology to countries which need cost-effective solutions to mounting environmental problems.[18]

3.2.7 Canada's Fossil Fuel Reserves

In most cities in North America, natural gas and fuel oil meet the bulk of space heating and hot water demand. As Canada's reserves of both natural gas and oil are limited, greater energy efficiency and more reliance on renewable fuels are worthwhile objectives. Improving energy efficiency is of particular interest given concerns with the greenhouse effect, acid rain and the destruction of the earth's ozone layer.

Cogenerated district energy can supplant some natural gas and oil-fired space heating in high- and medium-density commercial, institutional and industrial load areas. This replacement can assist in making Canadian natural gas and oil reserves available for a longer periods of time and/or increase the volumes available for export.

While CHP may not be practical in all situations, the potential for hot-water, long-distance transport of thermal energy to reduce the growth in Canadian demand for crude oil and natural gas appears significant, although difficult to estimate at this stage.

3.2.8 Safety

In eliminating the need for individual furnaces, CIES do away with the need for individual oil storage tanks, oil tanker activity and related risk of oil spills, and refinery loads and emissions. The overall impact is a reduction in the risk of leaks and ground water contamination. Community integrated energy system heat exchangers are quieter, cleaner, safer and smaller than existing units and the systems use trained personnel whose full time job is safe and efficient production and distribution of thermal energy. Therefore, insurance costs should be commensurately lower for CIES than for on-site heating systems.

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[17] See K. Morgan MacRae, *New Coal Technology and Electric Power Development*, CERI Study No. 38 (Calgary, Alberta: Canadian Energy Research Institute, April 1991).

[18] Ibid.

3.2.9 Water Use

Conventional thermal power plants consume large quantities of water in the production of electricity. Building cooling towers consume large amounts of water, producing water vapour plumes that increase the incidence of fog and potentially modify local climates by increasing rainfall and humidity. This water consumption is substantially reduced with CHP because the waste heat is used in district heating and cooling rather than being vented into the atmosphere or dissipated into nearby lakes and thereby increasing the thermal pollution of Canadian lakes.

3.3 Community Benefits

A modern district energy system can be a useful selling point in retaining and attracting business to a community. District energy can become a catalyst for urban revitalization by providing a reliable, low-cost energy source. Community integrated energy systems often allow for the use of energy resources indigenous to the community that cannot be used for other purposes, while at the same time providing increased protection from energy market fluctuations and ultimately providing for greater economic stability. A community integrated energy system may also became a significant source of income for the community.

Additional benefits include: a cleaner environment that makes the community a more desirable place to live, increased employment opportunities that ultimately result in improving the local tax base, and possibly a solution to the problem of garbage disposal.

3.3.1 Urban Waste

A beneficial aspect of urban waste is that it can be burned and used as a supplemental fuel for steam generation. Community integrated energy systems represent a promising customer for steam recovered from waste-to-energy facilities and a near-term means by which Canadian cities can make the transition to renewable energy sources. Municipal energy-from-waste plants can provide a stable, reliable source of energy, especially where the district energy system has a summer cooling load as well as a winter heating load.

Waste incineration is of increasing interest as waste landfills are becoming filled to capacity in many locations and landfill sites with suitable characteristics are becoming increasingly difficult to find. Proponents of incineration-based CIES argue that it makes more and more sense for many Canadian communities--**why bury or store something that has no additional economic use, when its energy can safely, economically and**

reliably be reclaimed. Municipalities in many parts of the world are now incinerating their refuse, thereby reducing the space required for waste disposal by as much as 90 percent.

Throughout the postwar period, the volume of solid waste produced in Canada by residential, industrial, commercial and institutional generators has grown steadily. In fact, Canadians are the most prolific garbage producers in the world, generating about 30 million metric tonnes of waste per year (16 million of that come from municipal and light industrial sources). Each Canadian generates an average of 1.7 kilograms of garbage a day. This compares to daily per capita figures for the U.S. of 1.6 kilograms, and 0.9 kilograms a day in Britain and Japan.

Canada's trash was seen until recently as a necessary by-product of life. Over the last decade, however, solid waste has become a **major** public issue in Canada as expanding volumes of waste and growing concern about where to dispose of it has forced Canadians to view waste as something that can no longer be cheaply disposed of, and easily forgotten.

Many landfills in Canada are rapidly approaching capacity or are being threatened with closure because they fail to meet environmental standards. Rising disposal costs mean that it is becoming more expensive to collect and dispose of our waste. In some municipalities, the landfill situation has become acute and there is additional strain on the capacity of landfills to absorb toxic or hazardous materials without posing grave threats to land, air and groundwater. Increased costs mean that there are greater incentives to seek out cost effective alternatives to traditional collection and disposal methods.

> **Over the next ten years, municipal governments must develop new waste management strategies that help divert large quantities of waste from local and regional landfills.**[19]

Several approaches are possible to link resource recovery and CIES. Refuse derived fuel (RDF), either fluff or densified, can be used as a supplemental fuel in conventional utility boilers. The combustion of unprocessed solid waste or RDF in dedicated boilers generally produces a low temperature and pressure steam more appropriate for heating purposes than electrical generation or industrial process applications.

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[19] Environment Canada, "The National Waste Reduction Handbook," An Introduction to Source Reduction & Recycling for Municipal Decision-Makers, February 1991.

More and more communities are evaluating waste-to-energy plants as part of their integrated resource management systems. Japan burns up to 50 percent of its waste, compared to only 10 percent in Canada.[20] Nearly every major European city generates part of its thermal energy with solid waste, then delivers it to users via CIES.

At the Baltimore Refuse Energy Systems Company (RESCO) in Maryland, 500 garbage trucks carrying up to 2250 tons of refuse visit the facility each day. The refuse-to-energy plant burns 85 percent of the city's and 25 percent of the county's garbage with only 10 percent being hauled away as ash. This significantly relieves the strain on local landfills. Baltimore's RESCO uses refuse to produce 60 MWs of electricity that is sold to Baltimore Gas and Electric Company, and steam that is sold to Baltimore Thermal's district heating system.[21]

In Nashville, the city and state set up Nashville Thermal Transfer Corporation, a non-profit corporation, to operate the world's first refuse-to-energy plant supplying both heating and cooling. Burning refuse to generate steam permits a fuel that originated in the community to be used to benefit the community. Lower costs result because the cost of operating the facility with waste fuel eliminates the usual fuel cost increases.[22]

In Ontario, Peel Region plans to have an incinerator up and running by the summer of 1992, selling the electricity it generates to Ontario Hydro. The facility will cut the volume of waste Peel sends to its landfill site by 15 percent and is urgently needed as efforts over the past ten years to procure another landfill site have been futile.[23] As landfills generate methane, a greenhouse gas, incineration helps to both displace fossil fuel use and reduces the GHG impact of urban energy use and waste disposal.

3.3.2 Economic Development

Community integrated energy systems can be an important component in community and economic development strategies, attracting and retaining development in a city. Reliable cost-effective systems attract industry and business. Important to many Canadian urban centres, CIES provides stable, affordable energy supplies that can help revitalize downtowns and surrounding residential neighborhoods by retaining dollars in local economies.

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[20] Miriam Cu-Uy-Gam, "Burning solution to water woes," Focus on Waste Management, *The Financial Post*.

[21] Turning Urban Waste Problems into Energy Opportunities, *District Heating and Cooling*, Vol. 76, No. 1, Third Quarter, 1990.

[22] Ibid.

[23] Miriam Cu-Uy-Gam, "Burning solution to water woes," Focus on Waste Management, *The Financial Post*.

District energy represents an investment in a city's infrastructure that uses initial capital investment to achieve long-term cost savings from a reduction in the amount of energy used. The ability to use several fuels can be engineered for each system to take advantage of local energy sources, such as municipal waste, sewage sludge and other fuels often available in the community. Regional air quality will also improve because emissions can be more closely controlled at a central heat source versus emissions control of the many smaller smoke stacks spread throughout the community.[24]

Construction of a CIES provides employment opportunities for skilled and unskilled workers for several years. Operation and maintenance of the system provides employment for others, while the availability of reasonably priced, stable thermal services means growth and business expansion that provides still more regional spin-off employment opportunities. By helping to create jobs and providing energy-wise incentives to locate downtown, district energy spurs economic development and downtown revitalization.[25]

3.3.3 Aesthetics

Cities with CIES have cleaner looking skylines, with one high chimney replacing the thousands of small, low chimneys and cooling towers. In the winter, buildings using district heating don't spew smoke from their rooftops and in the spring and fall, buildings with district cooling are free from cooling tower plumes.

Cooling towers, necessary in buildings that do not use district cooling, have always provided architects with a challenge as they are usually industrial in appearance, noisy and cause a plume for part of the year. If the cooling tower is located on the roof, condenser piping must be installed from the chiller (most often located in the basement) to the building's rooftop, resulting in lost leasable space on each floor. This can be as much as 18 square feet per floor, or thousands of dollars in foregone revenues. Using district cooling means that capital costs are avoided as are the aesthetic and maintenance concerns and design time associated with conventional electrically-driven chillers.

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[24] District Heating and Cooling Committee, "District Heating and Cooling in the United States," *Strategic Planning and Energy Management*, Fall 1987.

[25] Edmonton Power, "District Energy, An Energy Initiatives of Edmonton Power," City of Edmonton, District Energy Development Phase, September 1991; and "District Energy, An Energy Initiative of Edmonton Power, Socio-Economic Factors Report," section 4, City of Edmonton, District Energy Development Phase, September 1991.

3.3.4 Social Benefits

District energy systems facilitate the use of solid fuels such as coal, wood, solid waste or other biomass since these fuels can be burned efficiently with appropriate environmental controls in a central facility. The local community benefits when local resources are used because energy dollars are recycled in the local economy.

For example, in Charlottetown, P.E.I. waste is used in the Parkdale incinerator to generate steam used for heating the Queen Elizabeth and Riverside hospitals, saving the two institutions about 3.3 million litres of heating oil each year. Sending the waste to the incinerator has helped reduce the volume of garbage going to landfill sites by 90 percent. The PEI Energy Corporation also uses locally available wood chips as fuel for its district heating system. Previously, about 90 percent of the city's energy dollars went outside the province, but now with locally available woodchips, only 25 percent of that dollar goes elsewhere.[26]

3.3.5 Air Quality Improvement

An important reason for introducing district energy is to improve the local environment. If the same fuel is used in the CIES as was used to individually heat buildings, there is a significant improvement in energy efficiency and reduced discharge of flue gases--SO_2, NO_x and CO_2.

For example, by the widespread adoption of district heating and a move to low sulphur fuel oil, Stockholm reduced sulphur dioxide emissions from about 55 000 tons/year in 1965 to about 12 000 tons/year in 1985 and projects a further reduction to 3000 tons/year in 1990. Similarly, SO_2 reductions of about 50 percent have been achieved in Helsinki, Finland.[27]

3.4 Building Owner and Tenant Benefits

Local residents, businesses, and industrial customers may receive the greatest benefit from a modern CIES network. Not only do they reap the benefits that accrue to all other members of the community, but they also enjoy the district energy benefits of stable, economically-attractive energy supplies. Some industries not only benefit from reduced energy costs, but may also find a new source of revenue by selling waste energy to the CIES and, at the same time, reduce operating costs associated with waste heat disposal.

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[26] Miriam Cu-Uy-Gam, "Burning solution to water woes," Focus on Waste Management, *The Financial Post*.

[27] Michael Wiggin, "Food For Thought: Is DHC the Answer to Our Global Energy Questions?" *District Heating and Cooling*, Vol. 74, No. 3, First Quarter, 1989.

Many building owners/tenants will receive additional benefits from being connected to a CIES. These include:

- simpler and cheaper operation, since a subscriber installation is, in most cases, practically maintenance free;
- safety of operation due to reduced fire hazards as a result of eliminating fuel storage on the premises;
- potentially lower insurance rates due to the reduced fire hazard;
- more space for other purposes, because internal floor space previously devoted to heating equipment will no longer be required and can be dedicated to revenue-producing uses; and
- increased reliability because district energy systems usually consist of several production units and can, thus, provide substantial backup capability.[28]

For building owners, district energy may be cheaper, more efficient and more reliable than an individual on-site heating plant. Problems associated with the maintenance of boilers, oil burners, hot water heaters and oil tanks are eliminated. There are no chimneys or flue gas ducts to be inspected, cleaned or repaired; no oil, coal or gas supplies to be monitored; and no maintenance costs. Compared to owning and operating an on-site boiler, conversion to hot water district energy can benefit the user through increased reliability, greater tenant comfort, reduced investment, operating cost savings, increased energy efficiency and greater fuel flexibility.

The equipment in the building heat exchanger station requires a minimum of staff attention for operation and maintenance. All equipment except the meter, that is usually maintained by the utility, can be monitored by the regular building maintenance staff. There is no practical need or regulatory requirement for full or partial attendance by licensed operators, as would be the case with on-site boiler operation. Compared to on-site boiler operation, district heating will save labour and maintenance costs and therefore result in additional savings in administrative and insurance costs for owners and tenants.[29]

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[28] Gordon R. Bloomquist, John T. Nimmons and Kevin Rafferty. *District Heating Development Guide, Legal, Institutional, and Marketing Issues, Volume I*, p. 8.

Customer surveys indicate the following major reasons for customer satisfaction with hot-water district energy systems.[30]

3.4.1 Proven Technology

District energy is a straightforward technology proven in many parts of Europe--Finland, Sweden, Denmark, Germany and Russia.

Additional research is not necessary to make it feasible. Technology is already available to enable energy for space and process heating and cooling to be supplied from industrial waste heat as well as from electric generating stations.

3.4.2 Reliability

Community integrated energy systems are built with standby heating capacity to ensure that heat is always available at the central plant. Distribution systems are generally designed with multiple loops to provide additional distribution reliability. Skilled central plant operation and bulk fuel purchasing (which often means fuel cost savings of about 40 percent compared to the cost of fuel purchased for individual on-site boilers) assure long-term efficiencies and fuel savings that individual building on-site plants cannot hope to achieve.[31]

3.4.3 Tenant Comfort

Tenant comfort is assured, as hot water provides even heating that is easily controlled, particularly compared to older steam heating systems.

3.4.4 Reduced Investment

In a new building, the owner avoids the cost of purchasing a boiler and associated on-site facilities. Owners of existing buildings facing repair or replacement of the on-site boiler can also avoid these costs.

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[29] International Energy Agency, *IEA District Heating, Advanced Energy Transmission Fluids, Final Report of Research*, 1990:R9.

[30] District Energy, St. Paul Inc., Annual Report 1990.

[31] International Energy Agency, *IEA District Heating, Guidelines for Converting Building Heating Systems for Hot Water District Heating*, 1990:R8 (Netherlands: Netherlands Agency for Energy and the Environment, 1990).

3.4.5 Reduced Operation Costs

By eliminating the need for on-site boilers, CIES reduce operating, maintenance and insurance costs as it transfers some or all of these costs and responsibilities from the building owner or operator to the district energy utility. The resultant savings in staff, administrative, electricity and fuel costs in buildings can be great.

3.4.6 Energy Efficiency

Conversion to district energy can result in substantial energy savings to building owners and tenants because on-site building boilers often operate at efficiency levels well below the manufacturer's claims.

For example, in the past several years Vancouver's Central Heat Distribution Limited has converted two buildings whose boiler performance did not live up to claims. After conversion, it took 7.59 billion Btus to heat the 1050 Pender Street building with district heating compared to 14.15 billion Btus before the conversion. After correcting for degree day differences, the average efficiency of the buildings' boiler plant was found to be only 53.9 percent.

The New World Harbour Side Hotel converted to district energy steam in 1988 because of its history of high boiler maintenance costs, and the imminent major expenditure the hotel faced in its boiler plant. After conversion, the hotel's boiler plant was shown to have been operating at less than 60 percent average annual efficiency. These real life efficiencies are greatly at odds with typical claims for on-site boiler efficiency of 75 percent--a significant cost often overlooked by engineering consultants charged with recommending heating and cooling systems to building owners.[32]

3.4.7 Fuel Flexibility

Due to economies of scale, district heating and cooling systems can cost effectively use a variety of energy sources, switching among heat sources depending on what is most cost effective at a particular time. This flexibility is generally not achievable in individual buildings.

3.4.8 Increased Storage

Community integrated energy systems permit more profitable and efficient use of building space compared with a conventional boiler, as CIES equipment occupies much less space in the customer's boiler room, and no oil tank or flue gas duct are required. The space saved can be used for other, productive purposes--more rental units, office space or hospital rooms.

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[32] Jim Barnes, Central Heat Limited, "Real Boiler Efficiency: Clearing Up the Questions," *District Heating and Cooling*, Vol. 75, No. 3, First Quarter, 1990.

3.4.9 Safety

A district energy system is safer than a conventional system since CIES customers do not store their fuel on-site, do not operate fired pressure vessels, and need not worry about escaping natural gas. This heightens safety and can reduce the building's insurance costs.

3.4.10 Smokestacks

With a district heating system there is no requirement for buildings to have their own smokestacks, boilers or cooling towers. This means greater building design flexibility, reduced capital and operating costs to the building owner, and improved building appearance and community aesthetics.

3.5 Conclusions

Community integrated energy systems offer Canadian urban communities major benefits and opportunities:

For Society

- flexibility in selection of heat source
- reduced dependence on a single heat source
- better utilization of fuel
- more efficient operation
- improved environment
- reduced emissions because flue-gas scrubbing and cleaning can be used more effectively
- district cooling can be made readily available using ammonia and heat-based technologies that can significantly reduce the use of CFCs
- improved energy efficiency that reduces all forms of emissions, resulting in less global and local pollution
- enhanced fuel flexibility, resulting in more cost effective operation.

For Communities

- improved community energy management and utilization
- a major role for communities in controlling environmental emissions
- greater potential for communities to utilize local energy resources
- energy dollars reinvested in the local economy
- benefits from improved economy and energy-efficiency

- cheaper fuel costs from improved efficiency, leading to more local employment, an energy supply less sensitive to price changes, more reliable energy supplies, and better energy security

For Building Owners and Tenants

- lower heating costs
- simpler and cheaper operation
- safety of operation
- more space for other purposes
- greater comfort
- increased reliability

Community integrated energy systems directly address some of the most problematic issues associated with growth in the energy needs of urban Canadians--renewed energy supply concerns, increases in fuel prices, and a growing concern about the deteriorating quality of our air and water. The combination of CHP and heat-activated cooling technologies contributes to solving both global warming and atmospheric ozone depletion.

Integrated energy planning and district heating and cooling should be more widely applied in Canada for economic, energy and environmental reasons. Many Canadian cities could readily upgrade or adapt old systems to district energy or install new systems for residential, commercial and industrial use if the right incentives were in place.

We turn now to examine some of the major barriers to greater CIES development.

Chapter 4

BARRIERS TO DISTRICT ENERGY

4.1 Introduction

The energy efficiency and environmental benefits of community integrated energy systems (CIES) are significant but there are as yet few, large operating systems in Canada. A study of district heating in Canada[1] concluded that district heating can be competitive with conventional heating in the space heating market, but that the level of market penetration is limited by non-economic barriers.

These barriers are well summarized in a recent report prepared for the Ontario Energy Board. "Builders provided the energy-using equipment, natural gas companies provided the gas and building owners bought the gas. Each actor has his own interests and nobody took responsibility for integrating the elements of the energy using system."[2] The principal reason that energy has been used inefficiently is that there has been a fractionalization of responsibility for providing the various components of the energy-using system. Lack of a regulatory mechanism with accounts for integrated resource planning is, in this regard, the principal reason for energy use inefficiency.

This section identifies some of the major barriers to district energy and identities various incentives and regulatory and planning changes needed to foster district energy projects. Only by making these changes will Canadians have the opportunity to reap the many district energy benefits outlined in the preceding chapter.

4.2 Knowledge, Know-how and Technical Skills

One of the main obstacles to CIES development in Canada is inadequate information and knowledge. There is a lack of appreciation among Canadian planners, architects, engineers, and the public of the overall benefits of this technology. In fact, there is limited acceptance by potential customers of a heating/cooling public utility providing a reliable alternative to individual gas or electric heating/cooling plants. This is true even where such utilities exist and where these utilities provide reliable and cost-effective service--Charlottetown, Toronto and Vancouver are prime examples.

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[1] Monenco Consultants Limited, DHM Energy Consults Ltd., K-Konsult, and Cogeneration Associated Limited, "The Realistic Potential for District Heating in Canada, Volume I," April 1985.

[2] MSB Energy Associated, Inc., "Report on Gas Integrated Resource Planning," prepared for Ontario Energy Board, June 10, 1991, p. 7.

To a large degree, district energy is considered a new technology by the majority of Canadians although it was used over 2000 years ago by the Romans and has been an integral part of energy planning in some European countries for over sixty years. Regardless, this misconception means that district energy faces the normal resistance to change that confronts the introduction of any new technology.

Many small and medium sized companies and public administrations do not have enough knowledge or adequate technical skills to evaluate energy saving technologies. This is exacerbated by the fact that virtually all managers are completely occupied with day-to-day business activities and can only engage themselves in the most immediately important tasks. As energy comprises a relatively small percentage of most Canadian business costs, energy is seldom on the business agenda, even in government circles. Competitive pressures, both continental and international, necessitate that **prosperity agendas** occupy centre stage. **Oftentimes this gives "second class" importance to energy efficiency, as the fundamental link between greater energy efficiency, the environment and greater economic prosperity is seldom made.**

Lack of information and knowledge exists at the energy consumer level, but it is also prevalent with Canadian architects, consulting engineers and installers. These groups have a remarkable influence on the investment decisions of builders, small and medium sized companies and public authorities, yet they are largely unaware of the potential of CIES technology. Most Canadian engineering firms are not conversant with the low capital-cost technologies that have been applied for years in Europe. Consequently, municipal CIES opportunities are not triggered because design and cost estimates submitted by Canadian engineering and architectural firms come in too high to merit consideration.

Because these consultants do not typically market the services that follow their design and equipment specifications, it is common for there to be increased focus on the design stage of project development, at the expense of verifying the commissioning of energy saving measures.

Engineering consultants often specify familiar, "middle-of-the-road" upgrade options rather than more comprehensive energy-saving upgrades, in order to minimize the risks of installation or potential performance problems. Further, as contract bidding emphasizes low first-cost rather than low life-cycle costs, more energy efficient measures are frequently replaced by low first-cost, less efficient measures.[3]

As district energy systems are capital intensive, it is imperative that engineering design be innovative in reducing capital cost. Canadian engineering and architectural consultants' lack of experience in district energy leads to overly expensive design and is a major loss for Canadians as too much capital is tied up in inefficient energy-using equipment. Canada's investment community is also largely unaware of district energy. This makes raising investment capital extremely difficult, particularly for small- and medium-sized project developers.

As Canadian gas and electric utilities struggle to meet future demands, they are increasingly receptive to demand-side management suggestions. Despite the fact that CIES technology would accomplish greater DSM, few Canadian utilities have acknowledged these DSM benefits because most do not fully appreciate district energy's potential to more effectively use energy and to improve the environment. **This is equally true of regulatory organizations charged with evaluating gas and electric policy, and economic and environmental planning at the provincial, municipal and federal government levels.**

Another barrier to broader acceptance of district energy is the absence of a well documented demonstration of district energy and up-to-date data on technical performance and cost effectiveness. This prevents municipalities and gas and electric utilities from seriously assessing CIES. Lacking this information, individuals will defer investing as these investments are often felt to be premature, ineffective, unsafe, or too costly for the savings they yield.

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[3] A Report to the Minister of State for Science and Technology-Energy Conservation Technologies and Their Implementation (June 1983). See also "The Economically Attractive Potential for Energy Efficiency Gains in Canada," Case Study #3 - Commercial (May 1991).

4.3 Capital Access and Profitability Expectations

District energy is a capital intensive technology that requires substantial front-end investment by the developer, and to a lesser degree by the subscriber, to replace or retrofit existing heating systems. In addition to the front-end capital investment, the subscriber retrofitting to a district energy system is faced with some inconvenience associated with the installation of the distribution system and the retrofitting of existing heating equipment. This disruption can contribute to consumer resistance,[4] though the CIES developers can often help by assuming a portion of subscriber costs.

One of the main constraints to development or expansion of a district energy system is raising funds for the large capital investment required as several years of negative cash flow result when new systems are installed. This stems from the lead time before the district energy system actually is placed in operation and begins to produce revenues, and from the gradual buildup of load over several years before substantial revenues are generated. Moreover, as district energy investment usually involves wider investment criteria than other heating systems, potential developers and the investment community often consider it to be a riskier investment than other supply options.

There is a reluctance among corporations and domestic consumers to invest in technologies that require large capital outlays. Companies typically prefer investments in productive capacity in preference to improving energy efficiency. Recent surveys have shown that for commercial and industrial customers, project payback must be under two years, and that payback under one year will improve market penetration significantly.

In most companies, all investments except those for infrastructure are decided on payback periods, not on internal rate-of-return calculations. Even where rate-of-return calculations are used, there is a disparity in rate-of-return expectations among energy consumers and energy suppliers. Energy supply companies typically require nominal after tax internal rates of return of 8 to 20 percent for major supply projects. Yet for energy efficiency investments, energy consumers request payback periods between one and five years--equivalent to nominal internal rates of return of 15 percent to more than 50 percent--well above those for supply investment. Analyses by Energy, Mines and Resources Canada show that firms seek a rate of return better than 25 percent (for a three year pay back) on energy efficiency investments, compared with a 10 to 15 percent return on production expansion.[5]

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[4] Monenco Consultants Limited, DHM Energy Consults Ltd., K-Konsult, and Cogeneration Associated Limited, "The Realistic Potential for District Heating in Canada, Volume I," April 1985, p. 1-41.

This disparity in rate-of-return expectations among energy consumers and energy suppliers leads to a bias in favor of supply investments. Estimates suggest that the effect of this intersectoral disparity of profitability expectations is at least a 10 to 15 percent distortion of energy saving investments.[6]

While the potential subscriber is virtually assured that he will experience some front-end costs and inconvenience in connecting to the CIES, benefits are perceived as less certain since they are typically based on extended payback periods and projections of the future cost of alternative energy resources. The demonstrated inability by government to predict the future availability and cost of energy supplies has many Canadians understandably skeptical and reluctant to participate in energy solutions that require substantial upfront capital commitments to obtain long-term future benefits in energy costs.[7]

Investors typically see no incentive to change their own installations to a system that may be advantageous from a national economy-energy-environment point of view but not from a private industry or individual viewpoint.

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[5] A Report to the Minister of State for Science and Technology-Energy Conservation Technologies and Their Implementation (June 1983). See also "The Economically Attractive Potential for Energy Efficiency Gains in Canada," Case Study #3 - Commercial (May 1991).

[6] Dr. Ing. E. Jochem, Fraunhofer Institute of Innovation and Systems Research, "How to Realize Economic Potential for Reducing Greenhouse Gases: The Role of Technology-Specific Programmes in Energy Efficiency," in *Energy Technologies for Reducing Emissions of Greenhouse Gases, IEA Experts Seminar, Volume 2, International Energy Agency, Paris, France, April 12-14, 1989*.

[7] Monenco Consultants Limited, DHM Energy Consults Ltd., K-Konsult, and Cogeneration Associated Limited, "The Realistic Potential for District Heating in Canada, Volume I," April 1985.

4.4 Separation of Expenditure and Benefit

A major investment barrier is that the person who makes the investment is not the one who receives the benefits, with the exception of owner-occupied buildings. The tenant generally does not differentiate on the basis of energy cost, for while these costs may be substantial in total, they are typically a minor percentage of total business expenses.

This obstacle is relevant not only for efficient energy use for space heating, but also for air conditioning, ventilation, cooling and lighting equipment in leased buildings. It is also important in the public sector where buildings such as schools, sport halls, hospitals or leased office buildings have different owners and users.

4.5 Difficulty in Siting Power Plants

Cogenerated district energy requires plant siting close to heat load, commonly the downtown core of the city. While the Canadian public seems supportive of actions to minimize environmental impacts, actions speak loader than words and rhetoric. "Not In My Back Yard" (NIMBY) sentiment often limits the resolve of municipal politicians to support actions, such as CIES, that would result in an improved local environment and contribute to Canada's commitment to stabilizing greenhouse gas (GHG) emissions.

In addition, the provision of new energy supply, even where it is as energy efficient as district energy, is perceived by some environmentalists as diminishing the commitment to reduce energy use. In many instances, this opposition continues despite the fact that district energy plants would lower regional and global emissions and provide an answer to growing urban waste disposal problems.

The shortsighted opposition of some environmentalists is a major barrier to CIES. It serves to strengthen NIMBY sentiment and diminishes the political and community support required to plan for and implement community integrated energy systems.

4.6 Coherent Government Policy

Owing to the significant capital cost of the distribution piping associated with district heating and cooling systems, taxation can be a major factor affecting the growth of privately-sponsored district energy systems. Presently, Class 34 Capital Cost Allowance (CCA) is the only federal tax incentive for the installation of innovative energy technologies, such as combined heat and power (CHP).

This incentive is an accelerated write-off on machinery and equipment designed to encourage business and industry to use energy efficiently, to decrease its dependence on oil, and to switch to renewable energy resources. A capital cost allowance can be claimed on a Class 34 asset over a three year period. The maximum claims are 25 percent of eligible capital costs in the first year, 50 percent in the second year, and 25 percent in the subsequent year (see Table 4.1).

Eligible equipment consists of two categories. The first is electrical generating equipment, production equipment and pipelines of a distributor of heat, steam generating equipment acquired to operate electrical generating equipment, and additions thereto. Two main types of equipment qualify in this category: (a) equipment used to produce heat where the fuel used is primarily wood or municipal wastes, (b) coal, lignite, peat, and (c) natural gas, coal gas. Industrial and/or district energy systems could utilize this provision to advantage. The second category is equipment that will generate electricity, including associated steam-generating equipment, provided fossil fuel is used at a rate no greater than 7000 Btu per kW.h. This could be accomplished either by the use of high-efficiency back pressure turbines or through a combined use of fossil fuels and municipal or wood wastes.

The chief benefit of investing in Class 34 assets is that profitable enterprises can defer some of their tax obligations and thus pay less tax during the first three years of ownership of the assets. As accelerated tax write-offs can only be claimed by the actual owner of the equipment, nontaxable entities such as municipalities and institutions are prevented from reducing equipment costs through tax-based lease financing. To qualify for the fast write-off, an asset must be certified by the Minister of Energy, Mines and Resources.[8]

The Class 34 rules are generous, if the tax deductions can be utilized during the first three years of a project's operating life (see Table 4.2). Unfortunately, due to the relatively meagre front-end economics of energy efficient projects, smaller developers can usually

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[8] MacLaren Engineers Inc, *Cogeneration Sourcebook*, prepared for Ontario Ministry of Energy (Toronto, Ontario: Ontario Ministry of Energy, September 1988).

TABLE 4.1

ASSETS THAT QUALIFY FOR CLASS 34 CCA[a,b]

A. *Heat Recovery Equipment and/or Systems* that are designed to conserve energy or to reduce the need to acquire energy by *extracting* and *reusing* heat from thermal waste (e.g., heat exchangers, condensers and associated pumps, fans, instruments and control panels).

B. *Small-scale Hydroelectric Generating Equipment* (including alterations which increase capacity) up to a total of 15 megawatts.

C. *Active Solar Heating Equipment and Systems* which furnish heat for *manufacturing* and *processing*, and/or space heating in a new building, and heating of water. These include some ground source heat pump systems which extract the solar energy stored in the earth.

D. *Equipment and/or Systems Used to Generate Heat by Combustion of a Fuel Other than Oil* (natural gas, coal, coal gas, lignite, peat, wood wastes or municipal wastes, or any combination thereof).

E. *Equipment and/or Systems Used to Generate Heat* by combustion of municipal wastes and/or wood wastes.

F. *Equipment and/or Systems which Produce Heat and Electricity*, provided the consumption of fossil fuel chargeable to the electricity generated is less than 7384 kJ per kW.h (7000 Btu/kW.h) of electrical energy produced.

G. *Equipment and/or Systems Employed to Recover Industrial Byproduct Heat*.

H. *Wind Energy Conversion Systems* that are fixed location devices designed to produce electrical energy (e.g., wind driven turbines, support structures, powerhouses, control, generating and conditioning equipment and transmission equipment).

SOURCE: Energy, Mines and Resources Canada, Class 34 Accelerated Capital Cost Allowance.

NOTE: Also eligible under categories D, E, F, G and H are the assets used to distribute heat and to generate electricity.

[a] Abbreviated list of the types of assets that qualify for a three-year write-off.

[b] Information presented is for reference only. For detailed information, readers should refer to the Tax Act.

TABLE 4.2

PROS AND CONS OF CLASS 34
(as it relates to district heating and independent power projects)

Pro	Con
	• Stringent regulations to qualify which are not always clear. Governments and utilities are not using a consistent approach to the determination of fuel efficiency.
• Attractive write-off Year: 1 2 3 25% 50% 25%	• Limited Application by investor.
• Promotes efficient use of fuels	• Even if a project qualifies, it can take ten years to use all of the Class 34 write-off.
• A high CCA helps large organizations with other energy related income	• No ability to pass benefits on to third parties and monetize the asset early to help to give projects sufficient leg up to be viable. The early years of energy projects are traditionally lean and hence often projects are unfinanceable unless sponsored by a large entity.
	• People will not jeopardize outside corporate or personal assets to utilize Class 34 created by a new project.
	• Tends to favour larger commercial entities (e.g., revenues of $100 million or more) which have taxable energy revenues versus the smaller entrepreneurial companies which would create and promote CIES projects.
	• Tends to favour larger commercial entities which have mature existing energy income to pool with "energy" income from new projects and hence utilize the Class 34 write-offs immediately.

SOURCE: Rob McLeese, Access Capital Corp., Toronto, Ontario, Memos dated September 20, 1991 and March 9, 1992.

only use the Class 34 write-offs over an eight to ten year period versus the popular misconception of being able to use them over the three year period allowed by Revenue Canada. The main factor limiting the use of Class 34 is the relatively small income before taxes and depreciation in the earlier years of a CIES project's life. Due to the large amount of interest expense associated with the high capital cost and low operating costs of CIES projects, there is little net taxable revenue against which to use the CCA in the first few years.

Large energy-related organizations, through their ability to use the Class 34 write-offs immediately against their energy-related revenues, have a significant advantage over smaller energy investors (see Table 4.3). These large energy-related companies often negotiate and receive a significant portion of the accelerated capital cost benefits associated with Class 34 when investing with the smaller developer. Large providers of equity capital (such as life insurance companies) can take advantage of the fast write-offs of Class 34 by putting equity into these projects, thereby increasing the energy revenues against which the Class 34 deductions can be used.[9]

In addition to the equity issues discussed above, there is considerable confusion over its application to district energy systems. While Class 34 appears to cover all costs associated with the development of a district energy project, there is a widespread belief that it would not apply to the costly piping systems integral to delivering cogenerated district energy to final customers. In fact, to determine whether the project's piping would be eligible for Class 34 CCA, an applicant can go to Energy, Mines and Resources Canada for a technical review and issuance of a "prior opinion" before spending money on a CIES system.[10]

While getting a prior opinion on CCA applicability is worthwhile, it would be far better to clearly enunciate what Class 34 does and does not apply to, so that potential CIES developers and the investment community are not confused. The existing situation is an impediment to district energy development and is confusing, particularly where the information for Class 34 clearly states that assets used

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[9] Rob McLeese, Access Capital Corp., memo dated, September 20, 1991.

[10] A certificate can only be applied for after capital costs are incurred and the equipment is installed and "ready for use". A "prior opinion" can be applied for at any time during the course of the project.

TABLE 4.3

SUMMARY OF FINANCIAL MODELS

	Class 1 "No Class 34 Options"	Class 34 "Present Rule"	Class 34[a] "Creating Tax Losses"
Minimum Required Hurdle Rate (percent)	20.0	20.0	20.0
Projected Internal Rate of Return (percent)	14.8	16.7	28.4
Total Equity (percent)	15.0	15.0	15.0
Interest Rate on Debt (percent)	11.75	11.75	11.75
Assets			
Class 1	140,372	28,074	28,074
Class 34	0	112,298	112,298
Total Assets (total capital costs)	140,372	140,372	140,372
Coverage Ratio on Debt (interest & principal)	1.3 X	1.3 X	1.3 X
Loan Term (years)	19	18	18
Loan Repayment assuming 100% dedication of cash flow (years)	15	13	11
Cumulative Net Income (20 years)	132,422	151,941	165,035
Cumulative Cash Taxes (20 years)	135,800	128,172	138,886
Cumulative Cash Flow to Equity Investor	79,853	122,932	136,026

SOURCE: Rob McLeese, Access Capital Corp., Toronto, Ontario, Memo dated September 20, 1991.

[a] Used to offset other income.

to distribute heat and to generate electricity are entitled to Class 34 CCA.[11]

The many levels of government in Canada--municipal, regional, provincial and federal--make it difficult to coordinate programs for the adoption of energy conservation technologies. At the provincial level, utility regulatory boards (e.g., Ontario Energy Board) usually have jurisdiction over district energy activities. Locally, building codes, subdivision regulations and zoning laws affect district energy systems. Federal, provincial and local environmental protection measures also effect CIES plans. Many programs seldom satisfy industry's need for specific information upon which to base investment decisions in conserving technologies, nor do they provide sufficient incentives for them to do so. Co-ordination among provincial government departments--e.g., Energy, Environment, Housing, Industry, and Municipal Affairs--is fundamental to CIES development in Canadian urban settings.

On the environmental front, while there has been considerable examination of ways to reduce greenhouse gas emissions by provincial governments across Canada, there is no full-cost accounting system yet in place that would account for the full-cycle energy efficiency gains and reduced emissions achieved through CIES applications. A major problem facing implementation of district energy is the fact that environment externalities, such as improved regional air quality and reduced carbon dioxide emissions, are not internalized in the project economics--a zero emission gets no credit.

Federal, provincial and municipal government policy across Canada has not recognized or supported the many advantages of CHP and CIES. Neither has it actively promoted or encouraged district energy development, use and expansion. As part of a comprehensive national energy conservation strategy, CHP is actively supported in the United States. In contrast, Canadian energy policy does not include measures aimed at promoting CHP. While more and more CHP projects are under discussion between provincially-owned electric utilities and private developers, CHP and CIES must receive broader support if Canada hopes to attain its commitment to the stabilization of greenhouse gas emissions at 1990 levels by the year 2000.

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[11] A committee composed of members from Energy, Mines and Resources Canada and Finance Canada is currently reviewing all aspects of Class 34. District heating is included in this review.

Outside of the actions of a small group in the Canada Centre for Mineral and Energy Technology (CANMET) of Energy, Mines and Resources Canada to support technology development, transfer and a greater awareness of district energy, there is little government support for district energy. There is also little evidence of active interest from municipal or provincial governments, outside of Edmonton and Charlottetown.

District energy proponents contend that greater municipal involvement is mandatory, aided by provincial support with the federal government responsibility being for research, development and technology transfer, if Canadians are to realize CIES benefits.

4.7 Gas and Electric Utility Attitudes and Policies

There is a need for Canadian electric utilities to recognize and support CHP opportunities. Many of Canada's largest, provincially-owned electric utilities favour CHP to a greater or lesser degree. Unfortunately, many of Canada's smaller, municipal utilities do not adequately appreciate the community benefits of regionally-dispersed, CHP-based district energy systems.

The current role of utilities--with one exception, Edmonton Power--is very much a watching brief. One would expect provincially-owned as well as municipal utilities to be more interested in the potential of district energy as a greenhouse gas abatement technology as they have all the skills and knowledge needed to realize the benefits of CIES projects. Their main concern is that they do not see their mandate in the distribution of heat. In addition, many utilities today feel pressured with a myriad of problems in planning and constructing new capacity alone, and therefore hesitate to take on the burden of what is essentially a new industry.

Splitting the savings obtained through the combined production of heat and electric power is another decisive factor for successful use of district energy. The principle of avoided costs is normally applied to the electricity produced as a by-product of heat production. This requires proper contracts to be worked out between power and heat producers. Such agreements are, of course, most easily established when power or fossil fuel companies are responsible for both products.

The difficulty in gaining access to the equity capital required to finance the capital-intensive infrastructure for CIES is compounded by current utility mandates, the fractionalization of energy supply, and existing competitiveness among different fuel types. When utilities build a power plant to increase energy supply, they expect to get their money back in ten to twenty years. When someone makes an investment in energy efficiency for a building, that person expects a payback within two to three years. There is direct competition by other regulated utilities, both public and private, that promote their product, rather than energy services, to building owners. To date, these utilities have been happy to supply a district energy utility as another fuel customer but have then counter-marketed in the service area of the CIES utility. Gas and electric utilities often need to expand their rate base in order to stay financially sound and provide an adequate return to shareholders. Consequently, district energy may be perceived as a threat to the fundamental objectives of these gas and electric utilities.

In summary, utilities exhibit notable disinterest in diversification into district energy. Until integrated resource planning (gas and electric) or environmental cost accounting become components of the Canadian regulatory process, this situation is not expected to change.

While utilities generally have stated that they are in favor of cogeneration, they are generally not looked upon as the instruments to provide financial incentives to encourage cogeneration. **Governments and their various agencies (e.g., Public Utility Boards) should therefore become actively involved in promoting and assisting in the development of CHP and district heating and cooling based community integrated energy systems.**[12]

4.8 Feasibility Study Costs

Feasibility studies are very expensive and time consuming. A simple, preliminary study for a district energy system for a large city might cost $50 000, with a detailed study running $500 000 or more. Lack of clear government support and direction adds to delays and increases costs. Federal and provincial government support to municipalities and to gas and electric utilities and private companies for district energy feasibility studies would help overcome this barrier.

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[12] World Energy Conference, "The Positive Effect of District Heating on the Environment," 14th Congress of the World Energy Conference, Montreal, Quebec, September 17-22, 1989.

For this to happen, it is important that federal and provincial government policy-makers recognize the important impacts CIES could have on improving environmental quality and earmark greater funds for feasibility studies. As district energy fits well with federal government Green Plan objectives, it is appropriate that some of these funds be diverted to Canadian CIES development, particularly if Canada hopes to stabilize GHG emissions.

4.9 Environmental Permits

While district energy systems will improve regional air quality, the lengthy process required to obtain the necessary approvals and permits can hinder the installation of a district energy plant. Groups considering CIES see this as an additional barrier to CIES development.

4.10 Planning Complexity

Some of the challenges faced by CIES arise in part from its inherent flexibility. District energy projects are typically complex and involve a large number of institutional, technological, legal and financial issues. They require strong, determined leadership for success.

Before a private or public entity can undertake the construction of a district energy system, arrangements must be established in areas of ownership, financing, operation, regulation, taxation, and permits. Involved in this are federal, provincial and municipal governments; financing institutions; gas and electric utility companies; potential customers; major commercial and industrial interests; and local interest groups. Any one of these parties can delay the progress of a district energy project.

Although each CIES network will produce energy and transport it to end users, each community will develop its own unique technical, institutional and financial structures. The construction and operation of large district heating systems requires, by their very nature, a high degree of planning and management (see Part II - Toronto).

A variety of factors must be considered:

- system size
- growth and planning
- system location
- transmission distance
- community dynamics

- local goals and problems
- alternative ownership schemes
- fuel availability
- federal law and policy
- provincial and local regulation
- end use requirements (including thermal fluid temperatures)
- load distribution
- alternative financing mechanisms

Whether district energy will achieve the benefits ascribed to it depends on how it is perceived by potential customers and how well it overcomes the various impediments to its implementation in Canadian urban communities.

Potential district energy customers need assurance of the long-term availability and reliability of competitively-priced thermal energy before they commit to long-term contracts for cogenerated thermal energy. The district energy company must provide the assurance and confidence of competitive rates and it must also assure a convenience and supply reliability exceeding that of traditional, individually-owned, on-site heating systems. These potential barriers cannot be resolved without provincial/federal and municipal government commitment to CIES and new policies that resolve existing institutional and market barriers.

To take advantage of the potential of CIES, new or expanded systems will have to address the challenges each market type poses. Commercial users generally require reasonable first costs with short payback periods for energy related investments. Customer disruption from construction must be minimized by careful planning, community involvement, and modern construction techniques. The simplest and least costly approach is to develop the system while installing or replacing other public services, such as water or sewer systems. Institutional markets are like commercial ones--they require space conditioning and have few process applications.

Industrial markets require reliability and straightforward price comparisons as fuel price plays a more important role for industrial markets than it does for other potential users. Some industries have low temperature heat requirements and are thus prospective district energy customers. In other instances, industrial processes yield large quantities of waste heat that can be captured and sold via a CIES to other customers.

4.11 Postscripts

In theory, perfect market performance would produce an optimal economic allocation of resources for producing and using energy, including an appropriate effort on efficient energy use. In practice, however, many obstacles and market imperfections prevent profitable energy savings from being fully realized. District energy is a classic example.

There are important institutional constraints to CIES and CHP, including: siting criteria for power plants, which have trended away from population centers; the attitudes of the electric utilities toward CHP; environmental rules that fail to recognize the value of increased energy efficiency; finance and investment; jurisdiction; rate and tariff structure; and public, business and investment community attitudes. The societal and environmental benefits of CHP-based CIES appear sufficient to warrant extraordinary steps in overcoming the barriers to development of this energy technology.

The principal barriers to widespread district heating and cooling (DHC) adoption have proved to be institutional, financial statutory, and regulatory rather than technical and physical. The resolution of these issues involves a complex balancing of competing priorities, and can be achieved only through coordinated action among the involved parties. While many of these issues can be resolved at the municipal level, some require resolution at the federal and provincial government levels.

Both private and public owner-investors must be assured of a fair economic return, in keeping with the risks involved in the costly development of new utilities and services. Legislative action is required to define policy and remove barriers to owner-investor assurance and confidence in the long-term economic feasibility of district heating and thus spur interest in and development of CIES.

There is a need for the Canadian market, planners and consulting engineers to become more aware of new technologies, options and costs associated with district energy. There is a need for engineers, designers, system operators, maintenance personnel and other professionals who can install and operate district energy technologies and processes.

The government should encourage and support the training of the full range of specialists needed and the

promotion of information supporting a broad cross-sectional understanding of CIES costs and benefits to Canadian urban communities.

Since investment to increase sales is preferred, increased investment in more energy efficient technologies will only take place if it is encouraged with additional financial incentives. The infusion of government financial support could be of significant assistance to district energy development if it were oriented toward sharing the burden and risks taken by CIES investors. For example, government loan guarantees with repayment tied to revenues following project payback is a strategy that merits examination by federal, provincial and municipal government(s). If district energy facilities could be financed at the lower interest rates now enjoyed by utilities, this could provide a strong incentive to CIES. European CIES experience offers many more insights into the appropriate roles for government (see Part II).

Risk aversion plays a major role in the decision not to participate in a CIES program--people fear the uncertainties involved with new technologies. If the utilities and/or government can reduce this fear directly or indirectly, customer behavior will be positively impacted.

CIES proponents contend that greater municipal involvement is mandatory, aided by provincial support, leaving federal government responsibility for CIES research, development, demonstration and technology transfer. How to effectively spur municipal involvement is the key question. **As in Europe, mandatory controls or standards requiring municipal integrated resource planning may be required to elicit the many benefits of district energy systems.**

Electric and gas companies, both at the provincial and municipal levels, have not generally been active in promoting CHP and district energy. Utilities should be more interested in evaluating the potential of district energy as a GHG abatement technology, as they have all the skills and knowledge necessary to construct and operate CHP and CIES projects. Their main concern is that they do not view their mandate as including the distribution of heat and in many instances view CIES as a competitive threat.

Clearly, governments ought to become actively involved in promoting the development of cogeneration and CIES. If cogeneration-based district energy facilities could be financed at the lower interest rates now enjoyed by utilities, this could provide a strong incentive to its greater use. A further incentive would be for energy produced by CHP to be sold to electric utilities at the utilities avoided cost of generating heat and power. Making allowance for the reduction in environmental emissions produced by CHP-based district energy systems is also imperative. Adjusting regulatory review processes (i.e., Ontario's Environmental Assessment Board and the Ontario Energy Board) to credit the reduction in emissions from district energy systems is also imperative.

As the potential for cogeneration is enhanced when excess electric power, heat or chilling can be made available, without restriction or penalty by the cogenerator to a utility or other user, policies that **actively** support integrated resource planning in urban areas across Canada are required in order to fully develop the potential for community integrated energy systems. Integrated resource planning, where regulators responsible for space heating (e.g., gas) and electric power hold joint hearings on regional energy needs (both heat and electricity), is an important strategic consideration. This was the principal reason for European CIES development and the attendant energy-economy-environment improvements.

Feasibility studies are expensive and time consuming. Federal and provincial government financial and analytical support to municipalities and to gas and electric utilities for district energy feasibility studies would help overcome this barrier. For this to happen, governments must earmark funds for feasibility studies. Green Plan funds seem an appropriate source for this funding, particularly if we are to stabilize GHG emissions in the next eight years.

We turn now to a more indepth discussion of changes required to place CIES on a level playing field.

Chapter 5

IMPLEMENTATION STRATEGIES FOR COMMUNITY INTEGRATED ENERGY SYSTEMS

5.1 Introduction and Synopsis

In theory, if a technology is cost effective, the market will adopt it. However, the reality is that the market-place is not perfect, and society may choose to have government encourage various technologies and practices that produce public benefits but that are not entirely accounted for in the market-place. District energy is a classic example of a technology not properly accounted for by the market-place.

As described above, there are various barriers to adoption of district energy for Canadian communities. Due to the counter-influence of vested interests in supply growth and because of various financial and institutional barriers, the market has exhibited comparatively little interest in district energy.

Attitudes about energy efficiency and the impact of traditional energy choices on Canada's environment are making today's media headlines. But, visible direction and encouragement by government is vital to ensure that real progress is made in the way Canadians use energy. **Today's market economy and regulations are simply not designed to promote energy efficiency and minimize environmental problems.**

To benefit from CIES technology, we need to let go of our current perceptions because progress is often limited by our perception of what is, rather than what could be. Government policy-makers with full support of the Canadian public must recognize the benefits of CIES and work through changes in policy, planning and incentive mechanisms to establish this vision. Unlike many other energy options, technology is not the main problem. CIES technology is readily available and commercially proven.

CIES offer important public benefits at the local, provincial and national level. The technology of hot-water district heating has proved itself in many other countries to be capable of providing electricity and thermal energy in a safe, reliable, fuel efficient, cost effective and environmentally compatible manner. District energy not only reduces emissions of conventional pollutants, but it also reduces emissions of CFCs and CO_2. Other benefits include enhancing Canada's fossil fuel resource base, energy supply flexibility and downtown revitalization. However, in spite of its many benefits, CIES in Canada are limited for the most part to large institutional complexes, government facilities, or university campuses--places where one authority is responsible for "community" planning.

For district energy to be considered in Canadian energy development, there has to be federal and provincial policy. For example, in many parts of Europe district energy is a top priority for improving efficiency and reducing environmental impacts (see Part II). Within Canada, however, most Canadians do not even know what district energy is. To ensure that CIES is used to address topical Canadian energy-environment-economy issues, coherent strategies are needed to overcome barriers such as existing legislation, regulations, standards, practices and attitudes. Various incentives, both financial and of a non-financial nature, together with changes in energy-environmental-economy planning are required to hasten CIES projects across Canada.

Making Canadians aware of district energy and its many benefits is required. But, this awareness must transcend broad-based marketing programs and CIES demonstration projects to be soundly rooted in the way we assess energy-environment-economy issues and how we resolve the impacts. Critically important is the need for a new regulatory processes and planning regimes--ones that can manage the many tradeoffs involved in assessing energy-environment-economy impacts. Through community Integrated Resource Planning (IRP), we must recognize that district energy will complement other utilities and benefit communities, utilities and customers, alike. Unless an Integrated Resource Planning regime is implemented, Canada's energy situation cannot be expected to change.

This chapter discusses a multiplicity of issues that need to be addressed to hasten district energy projects in Canada and sets the stage for recommendations presented in the next chapter.

5.2 Learning from the Europeans

Municipal governments have played a major role in the development of district energy in Europe and are a driving force behind the renewed interest in CIES in the United States. In Denmark, Finland and Sweden, almost all district energy systems are managed by municipal utilities.

European countries have long recognized the benefits of community integrated energy systems and their positive impact on the environment. In European countries, many ways to hasten CIES development have been found:

- grants for feasibility studies;
- grants for demonstration for new techniques;
- investment grants of varying percentages;
- special depreciation rules;
- tax exemptions to combined heat and power (CHP) plants; and
- politically fixed low tariffs for the supply of heat and higher tariffs for electricity produced than corresponding to the avoided costs of electricity generation.

Where such measures did not suffice, governments have regulated the issuing of permits to build new power plants, giving licences to plants only where they are designed as small decentralized CHP power plants that are integrated into the community's district energy system.

Many European countries that have chosen to use CIES have developed comprehensive energy plans to rationalize the development of competing energy forms and thereby avoid the construction of competing capital-intensive energy distribution systems. A long history of municipal government involvement in the energy sector has also had a positive impact on the development and implementation of these plans.

The major contributing factors to the extensive development of CIES in European countries have been:

- government structures that permitted detailed integrated resource planning in the energy sector by municipal, regional and national governments;
- a long tradition of cooperative action at the local level that improved the acceptability of local district energy projects;
- a willingness by the public to accept controlled access to energy alternatives and the principle of compulsory connections; and
- substantial government financial and legislative encouragement for the development of CIES directed to energy efficiency, an improved environment, the use of indigenous resources and greater industry competitiveness.[1]

5.3 Integrated Resource Planning

The regulatory structure that would best support implementation of CIES across Canada requires innovation in Canadian energy-environment-economy planning. The simplest and most cost-effective way of promoting Canadian CIES development would be to delegate IRP heat plan responsibility directly to Canadian municipalities as has been done in Europe. Denmark, Sweden and Finland are notable examples of the success of district energy and the many positive employment, environmental and community impacts resulting from CIES (see Part II).

The reason that Canadian energy use has been inefficient is that there has been a fractionalization of responsibility for providing the various components of the energy using system. Builders provided the energy using equipment, natural gas companies provided the gas, and building owners bought the gas. Each actor had his own interests.

To become more energy and environmentally efficient and to ensure minimal impact on the Canadian economy, we need to develop institutional mechanisms that look at the big picture. A process used extensively in Europe and one that is making inroads in U.S. and Canadian electricity planning that could help foster CIES implementation is Integrated Resource Planning. IRP is a method of planning where the expected demand for heat and electric services is supplied from the least costly mix of supply additions and demand management options. With IRP, the full societal cost of energy resources is factored into the resource planning process, resulting in reduced environmental affects.

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[1] Monenco Consultants Limited, DHM Energy Consults Ltd., K-Konsult, and Cogeneration Associates Limited, *The Realistic Potential for District Heating in Canada, Volume I*, April 1985.

This broad-based planning approach is particularly important for urban communities as district energy systems require close proximity to urban areas to be cost-effective, but areas available for power plants in urban areas are usually very limited. Long-range IRP with cooperation between local authorities, gas and electric utilities, and the public is therefore essential.

5.3.1 History

From the information presented in Chapter 4, it would appear that the "walls" to CIES in Canada are indeed high. However, nothing depicts "easy answers" to seemingly complex issues as succinctly as the recent fall of the Berlin Wall. The same is true of all the barriers that appear to stand in the way of greater Canadian CIES development. In fact, when you look closely, existing barriers to CIES can be surmounted quite easily. All it requires is breaching a wall--in this case lack of awareness--and shoring up our fractionalized approach to Canadian energy-environment-economy planning. The answer here is Integrated Resource Planning. These solutions are not idle speculation. In fact, they are a time proven approach used first in the ancient Roman Empire and later by the Scandinavians of the late 19th century.

The first people to use district energy were the early Romans--over 2000 years ago. Unfortunately, this technology was lost to western Europeans until the late 1880s.[2] The Romans also used a decision-making technique that proved inconquerable--Integrated Resource Planning. IRP permeated Roman city and fortress design, how the Roman armies were organized and how they moved and how they planned their roads and communications.[3]

The Scandinavian countries recognized the importance of IRP when, faced with the same benefits and barriers to district energy discussed in this study, they chose to support community Integrated

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[2] See Chapter 2 on the early history of district energy.

[3] James Simon, *Ancient Rome* (Toronto, Ontario: Stoddart Publishing Company Limited, 1990); Ruth Whitehouse and John Wilkins, *The Making of Civilization-History Discovered Through Archaeology* (London, England: Roxby Press Limited, 1986); and F.R. Cowell, *Everyday Life in Ancient Rome* (New York, New York: G.P. Putnam's Sons, 1961).

Resource Planning. Finland, Denmark, and Sweden all chose to vest decision-making with their municipalities--those parties closest to the impacts and those that had to live with energy planning decisions--both good and bad. In delegating responsibility for energy and environment for municipalities to municipalities, these countries chose the most expedient and cost-effective approach to energy-environment-economy issues and impact resolution. These municipalities in turn recognized that district energy was the most effective tool available to them to reduce energy costs. Moreover, as district energy evolved into networks of systems that were interconnected, other benefits became evident--an improved local and regional environment, greater local employment, and greater use of indigenous resources.[4]

By pushing responsibility for things that impact municipalities down to the municipal planning level, the Scandinavians did the same thing the ancient Romans did in their city states. They pushed decision-making down to the level where it made the most sense. Not surprisingly, this downward push also caused far greater citizen involvement in the decision-making process--a tactic many Canadians believe is essential to dealing with today's perplexing energy-environment-economy issues. The **NOx/VOC Management Plan**, the **Green Plan**, the Canada-wide **Environment and Economy Roundtables** and **Alberta's Clean Air Strategy** are all indicative of this trend to greater stakeholder participation and Integrated Resource Planning across Canada.

5.3.2 What is Integrated Resource Planning?

Individual technical solutions for rational energy use seem to be difficult to incorporate into an effective energy policy design. The design of an energy policy package should reflect the obstacles and market imperfections for specific energy consumer groups because all existing obstacles have to be reduced or removed at a given time.

A good example is the refurbishing of buildings in the residential sector. Refurbishing of buildings is mostly an individual event and the obstacles are numerous. Therefore, a package of instruments has to be designed:

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[4] See Volume II for a description of the benefits from district energy in Denmark, Finland, and Sweden.

- advanced education and training of architects, planners, and craftsmen is necessary to improve the diffusion of knowledge and technical skills;
- information and education of landlords and homeowners is needed to improve their knowledge and understanding;
- this causes a need for professional advisors to perform audits and give practicable recommendations;
- these energy audits may be considered too costly by the landlords or homeowners and a subsidy for energy audits may therefore prove to be cost-effective;
- the subsidizing of investments may be bound to a registered energy consultant and a formal heat survey report;
- the government may create a market for these services by a regulation that demands a formal heat survey in the case of a changeover of tenants in dwellings or a change of ownership of houses and buildings; and
- finally, an investment subsidy scheme for specified groups may be justified to overcome financial bottlenecks.

Community integrated energy systems allow the district energy utility to buy and sell heat and cooling within a community, thus achieving energy, economic and environmental benefits. For example, waste heat recovery from sewage treatment plants could be used to displace fossil fuels or, like Toronto, offer a possibility of taking cold water from Lake Ontario and displacing some 300 MWs of electricity that would be needed to run electrically-driven chillers. The heating or cooling produced can typically be distributed around a community through buried pipes to serve various thermal energy loads and then returned for reheating or cooling. In fact, the thermal network is more than a heating or cooling technology, it is a community energy broker that makes possible many linkages of sources and demands for heating and cooling that might not be possible on an individual basis.

In Europe, for example, many district energy systems buy and sell industrial waste heat or recover and upgrade heat from sewage treatment plant effluents. These systems not only increase the overall efficiency of energy use in the community, but divert community energy dollars previously flowing out of the community back to those who are willing to make waste heat available on favorable terms and conditions. Frequently communities are near to energy resources that community businesses, institutions, and residences could not individually use. This might include wood wastes or cold water for chilling in deep lakes or groundwater sources.

To deal effectively with such large, multi-purpose systems within today's urban environment, requires a radically different approach to energy planning in communities. In order that the full potential for CIES is recognized and planned for, as is the case in many European countries, a broader approach--one that goes beyond the fractionalization that has characterized Canada's market approach to heat and electricity planning--is required.

Obstacles to energy savings and emission reductions are related to each other and have typical patterns in the energy consuming groups. These group-specific patterns have to be matched by similar patterns of measures of energy policy (see Figure 5.1). Individual instruments, such as information, training, grants or energy taxes may produce very poor improvements in energy efficiency.

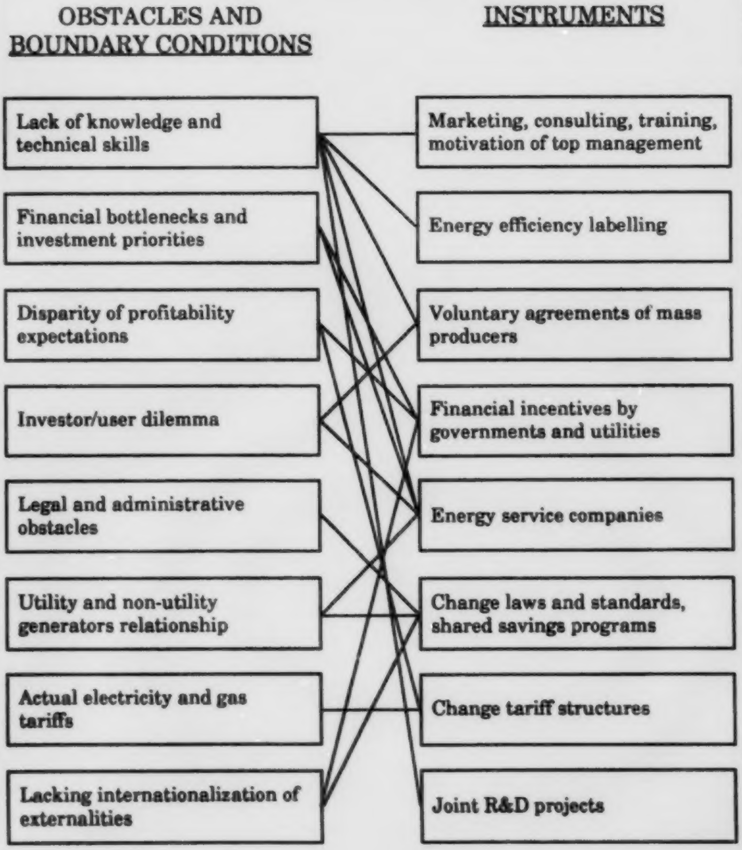
Alternatively, integrated energy policies that consider the interdependence of regulations, consulting, training programs and financial assistance have been very successful. For example, Danish and Swedish residential programs have this multi-measure character and the results have been impressive. Between 1972 and 1987, annual consumption in space heating dropped by 45 percent (from 1.26 to 0.7 GJ/m^2) in Denmark and by 35 percent in Sweden.

Integrated Resource Planning includes consideration of district energy as a demand-side management tool as well as an alternative means of meeting end use energy requirements. This can be best accomplished by redefining the Canadian regulatory process to focus on determining the approach that will provide the lowest cost per unit of useful energy provided, including consideration of externalities.

Integrated Resource Planning is an expanded method of planning where the expected demand for heat and electric services is met from the least costly mix of supply additions--energy conservation, energy efficiency improvements and load management techniques. Integrated Resource Planning integrates evaluation of demand-side

FIGURE 5.1

INTERRELATIONSHIPS BETWEEN MARKET IMPERFECTIONS AND POLICY MEASURES TO ALLEVIATE THEM


OBSTACLES AND BOUNDARY CONDITIONS
INSTRUMENTS
Lack of knowledge and technical skills
Financial bottlenecks and investment priorities
Disparity of profitability expectations
Investor/user dilemma
Legal and administrative obstacles
Utility and non-utility generators relationship
Actual electricity and gas tariffs
Lacking internationalization of externalities
Marketing, consulting, training, motivation of top management
Energy efficiency labelling
Voluntary agreements of mass producers
Financial incentives by governments and utilities
Energy service companies
Change laws and standards, shared savings programs
Change tariff structures
Joint R&D projects

SOURCE: Dr. Ing. E. Jocham, *How to Realize Potentials for Reducing Greenhouse Gas: The Role of Technology Specific Programs*, Energy Technologies for Reducing Greenhouse Gas Exports, Volume 2, April 1989, p. 387.

and supply-side resources. The Ontario Energy Board (OEB) intends to examine the elements of IRP within the context of gas distribution, storage, transmission and rate setting by Ontario's three major gas distribution companies in the spring of 1992.

The IRP exercise helps utilities "consistently assess a variety of demand and supply resources to cost-effectively meet customer energy service needs. Key characteristics include: (1) explicit consideration of energy-efficiency and load-management programs as alternatives to some power plants and new supplies of natural gas; (2) consideration of environmental factors as well as direct economic costs; (3) public participation; and (4) analysis of the uncertainties and risks posed by different resource portfolios and by external factors."[5]

Some of the specific objectives of the IRP planning process are to continue to provide reliable service, equity among ratepayers and a reasonable return on investment for the utility, while addressing environmental issues and achieving the lowest cost to the utility and the consumer. Successful implementation of IRP requires a fundamental refocussing of the utility's mission, from being solely a supplier of natural gas (or electricity) to a more comprehensive view of being a provider of energy services. Under IRP, the utility is responsible for analysing the energy uses of its customers, evaluating alternative energy use options, and using its position as an energy supplier to put in place the most economically advantageous combination of alternatives. The result of the utility taking this perspective will be reduced long-term costs to utility customers.[6]

Integrated Resource Planning evolved in Europe in the CIES-approach to mandated municipal responsibility for energy planning and later in the United States in the electricity sector. To date, the bulk of the U.S. effort has focussed on IRP for electric utilities, although there is a growing effort to transfer IRP concepts and practices to natural gas utilities. In recent times, there has appeared increasing acceptance of a societal cost-effectiveness perspective, as opposed to a simple utility perspective or a ratepayer perspective. Associated with the trend towards a societal perspective is an increasing emphasis on incorporating indirect costs or externalities into IRP. For example, a growing number of U.S. regulatory commissions are moving toward direct monetization of external costs.

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[5] Discussion paper on *Demand Side Management in Canada's Natural Gas Industry* (February 27, 1991), p. 1.

Questions of interfuel competition and competition between regulated and non-regulated suppliers are also taking increasingly prominent places in the IRP debate. The adoption of a societal perspective for analysis is consistent with comprehensive consideration of inter-fuel program impacts, and several jurisdictions have moved in this direction.[7]

As cited in a recent report by the Ontario Energy Board, the potential benefits to natural gas consumers in Ontario from the adoption of IRP are large. These benefits include cost reduction, environmental benefits, an open access process and a reduction in financial and regulatory risk for the utility. An integral part of the move to IRP is an understanding and acceptance of the role of natural gas utilities as providers, not of gas, but rather of energy services--it makes no sense to burn expensive gas to meet customers needs when less expensive options are available. Why burn gas to replace heat lost through leaks in a home if those leaks can be closed at lower cost?

The IRP process also yields environmental benefits. If the IRP mandate is defined so as to include an overall societal perspective in the resource planning process, the utility (with assistance from the regulatory agencies and interested intervener groups) will have the responsibility to assess the societal impacts of alternative resource options and include those impacts in the resource selection process. Under this approach, the full societal cost of energy resources is factored into the resource planning process, resulting in reduced environmental impact.

An integral part of IRP is participatory democracy--i.e., public meetings and hearings including all stakeholders--where interested parties have the opportunity to present their views and ask questions of participants. Public involvement in the gas planning process will lead to greater public understanding of natural gas and its role as part of the energy resource mix, including expectations with regards to availability and prices, the role of gas vis à vis other energy sources such as electricity and oil, and alternatives to the use of gas.

Adoption of IRP would also provide several benefits to the utilities themselves. The first is a reduction in business risk. A major source of business risk is uncertainty about the future. By including more options of both a supply-side and demand-side nature in its

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[6] MSB Energy Associates, Inc., *Report on Gas Integrated Resource Planning*, prepared for Ontario Energy Board, June 10, 1991.

plans, a utility will be better positioned to deal with future uncertainty. For instance, by changing a company's mandate to providing heat instead of providing gas that supplies heat in individual on-site systems, the gas utility can continue to supply gas but would also likely consider options to gas such as centralized, low cost sources of heat--municipal solid wastes or IGCC units that can burn a multitude of fuels including natural gas.[8]

Unfortunately, a potential problem with IRP arises because in most Canadian jurisdictions there is a plethora of government agencies responsible for various segments of the energy-environment-economy linkage.

For example, Ontario Hydro is not under the jurisdiction of the Ontario Energy Board, whereas a comprehensive IRP process would coordinate the planning of electric and gas utilities as well as other fuels. The Ontario Energy Board has only a review function with respect to Ontario Hydro, an indirect competitor of the gas utilities, and Ontario Hydro is engaged in its own IRP process before the Ontario Environmental Assessment Board. Although Ontario Hydro has its own IRP process, the lack of coordination between Ontario's gas and electric IRP processes may result in fewer societal benefits than would be the case where one, comprehensive IRP process was used for both heat and electricity.[9]

Common sense dictates that we do away with the inefficient duplication of regulations that stand in the way of greater energy efficiency, an improved environment and greater economic prosperity for Canadians. Only one IRP process is required, as is true in many European jurisdictions--a process that would jointly account for community/regional electricity and heat needs.

Using Ontario as a case in point--a joint hearing chaired by the Ontario Energy Board and the Environmental Assessment Board could be undertaken to ensure the best fit of demand- and supply-side resources for the provision of both heat and electric power. The Ontario Ministry of Energy could provide important input by assessing the least-cost impacts of other IRP strategies on the Ontario economy.

The P.E.I. Energy Corporation provides an interesting template of a comprehensive IRP. The P.E.I. Energy Corporation is

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[7] Ibid.
[8] Ibid.
[9] Ibid.

somewhat unique in Canada in that it has many of the characteristics of a European municipal district heating company and acts primarily as a project developer, but does not suffer the private sector's limiting return-on-investment criterion. The P.E.I. Energy Corporation is a crown corporation whose mandate is to identify and demonstrate approaches to using energy more efficiently; using alternate, cost efficient sources; directed to evaluate promising energy technologies--and to putting them into place. As such, it does not have a mandate to specialize in one particular energy area but can evaluate all options to arrive at the most promising energy system.

The organizational structure and flexibility of the Corporation has allowed it to implement projects that would not otherwise have proceeded. Therefore, it would appear that the creation of a special unit within the municipal/provincial government to seek out and develop energy projects along the lines of an independent agency is something that might be a useful instrument promoting CIES implementation across Canada. However, the complexity associated with planning for district energy systems requires that such a municipal/provincial agency have a full-time commitment to district energy.

5.4 Full Cost Accounting and Integrated Resource Planning

Established energy forms are typically offered to Canadian consumers at their average cost of production--a cost often below the long-run marginal cost of supply. District energy as a new heat source must construct and develop its system at current costs. That places district energy or any new energy technology at a major economic disadvantage.

To minimize environmental affects, energy prices should include the externalities associated with production and use of energy, commonly termed full cost accounting. Many external effects are not quantified and monetized today--the psycho-social costs of serious illness or deaths as well as the costs to the health system; the environmental effects of the production of intermediate goods used for investments in energy systems and the operation of these systems; the environmental effects of all stages of the fuel cycle; the full costs of climatic changes; and hidden subsidies for energy systems. For example, if district energy's chilling capability was credited for its ozone depletion potential, the economics of heat-based chilling would substantially improve.

It is important to use environmental concerns and to identify them and quantify their impact. Although research has been and is being undertaken into full cost accounting for externalities, costs have proven extremely difficult to quantify, as our understanding of the impact of emissions and waste streams on the environment and the economy is in its infancy. Some analysts suggest that energy policy should consider a tax on energy use or that financial incentives for energy efficiency improvements should be guaranteed by government regulation, subject to various performance criterion.

In the absence of actual costs that account for the adverse environmental impacts of greenhouse gas (GHG) emissions and urban waste streams, Integrated Resource Planning should be used as a planning vehicle. In many jurisdictions in the U.S., for example, IRP is used to subjectively weigh environmental externalities and the energy-environment-economy costs and benefits of energy and non-energy factors in electricity supply planning. Ontario Hydro's IRP process offers a good starting point for developing a comprehensive energy-environment-economy regulatory scheme that could apply to both heat and electricity.

5.5 Why Government Commitment?

5.5.1 Externalities

Potential customers are hesitant to commit to long-term contracts for thermal energy without knowing details of delivered cost and operating reliability. Reluctance to invest in CIES is exacerbated because CIES require large capital outlays and long payback periods. These barriers cannot be resolved without government policies that support the cost and efficiencies of CIES and financial incentives that overcome existing institutional and market barriers.

Environmental externalities also represent an important reason for examining sharing of risks so that CIES projects might go ahead. As indirect benefits (i.e., emissions reduction) do not accrue to the CIES developer, the value of these benefits may be an appropriate benchmark for government support of CIES projects. Governments might play a catalyst role in helping to promote acceptance and construction of CHP-based district energy projects based in part upon the demonstrated improvements in environmental quality this technology offers Canadian communities.

5.5.2 Government--Canada's Largest Landlord

The potential developer of a district energy project will require a considerable initial and continuing subscriber heat load to average down the large fixed costs associated with the capital investment. A mandatory hookup policy or long-term heat supply contracts to transfer some of the financial risk to subscribers would therefore be favoured by developers, although a mandatory hookup policy would probably be unacceptable in Canada. Historically, individuals have been free to choose (within the limits of requirements for public safety and environmental considerations) whatever heat source was accessible to them. Furthermore, long-term heat supply contracts or mandatory hookup will also be unacceptable since similar commitments are typically not required by competing, conventional energy sources.

In Denmark, while compulsory connection to planned CIES networks exists at the municipal level, Danish municipalities usually impose obligatory connection only for new buildings. The need to reduce environment pollutants associated with energy use, however, has recently seen a change in this policy. Energy 2000 now permits Danish municipalities to evaluate and require existing buildings to connect to CIES (see Part II).

An approach that is more in keeping with Canadian's freedom-to-choose and governments' support of new technology is warranted. Federal, provincial and municipal governments are owners of, and tenants in, massive amounts of commercial office space in the downtown core areas of Canadian cities. For example, the federal government is the largest single "business" in Canada, with expenditures of $125 billion and over 585 000 public servants and employees of Crown corporations.[10]

As Canada's largest commercial landlord, the federal government owns or leases 25 million square metres of office space. There are more than 50 000 buildings and facilities in its inventory, ranging from office buildings to laboratories, parks and military bases. Canada's provincial, regional and municipal governments also own or lease many more millions of square metres of office space; most of that is located in the downtown core of Canadian urban communities. These buildings can be a vital part of the critical mass necessary for financially sound community integrated energy systems across

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[10] House of Commons, Standing Committee on Environment, *Out of Balance...The Risks of Climate Change* (March 1991), p. 60.

Canada. If government took advantage of its position and made energy a determinant in lease and design decisions, it would have enormous leverage in improving energy efficiency and promoting the implementation of CIES.

A policy of connecting government-owned facilities on a long-term contractual basis to a CIES and favoring the leasing of commercial office space from buildings connected to CIES would go a long way to providing district energy projects with the important initial baseload necessary to make CIES economically and financially attractive across Canada.

Government commitment to use district energy can be viewed from two perspectives. District energy provides lower capital cost for heating and cooling when all costs, including capital, labour, maintenance, supplies as well as fuel, electricity and environmental impacts are accounted for. An equally important reason for government support is that government procurement of new technologies typically leads to rapid advances in those technologies, resulting in accelerated market introduction and enhanced overall economic gain for Canada.[11] Export opportunities for Canadian district energy companies and consulting engineers would also be enhanced.

5.6 CIES--A Shared Responsibility

The large capital requirements associated with CIES may constitute a major barrier to proposed project financing. The perceived newness of the technology, its capital intensive nature, long payback period and the substantial competitive pressures to which the project would be exposed, all serve to increase the perceived riskiness of district energy in the minds of potential investors. Ownership of a CIES project by gas and/or electric utilities and/or municipalities having relevant related experience, established credit worthiness, reasonable access to capital and possibly government guarantees would serve as a major reduction in the perceived risk of district energy projects to customer and investors, alike.[12]

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[11] Mark Spurr, *Public Policies for Encouraging District Heating and Cooling*, International District Heating and Cooling Association, San Francisco Annual Meeting (June 24, 1991).

[12] Monenco Consultants Limited, DHM Energy Consults Ltd., K-Konsult, and Cogeneration Associates Limited, *The Realistic Potential for District Heating in Canada, Volume I*, April 1985, pp. 1-44.

Canada's existing energy utilities are probably the best equipped organizations to deal with the barriers impeding Canadian district energy development. These utilities typically operate capital-intensive systems with long-life assets and extended payback periods. Due to their continuing need for capital, they have established their credit-worthiness in financial markets and thus have reasonable access to the longer-term financing that is required to produce a reasonable return on capital-intensive projects. Utilities also work with the longer planning horizons that are required in the development of CIES and have developed, in operating their current line of business, many of the administrative, organizational and technical capabilities required to cope with the regulatory and operating requirements of district energy systems.

5.6.1 Constitutional Delegation

Although the federal government can encourage certain types of considerations or processes, Canada's constitutional division of responsibilities means that Canada's provinces and municipalities will decide how they wish to plan for energy-environment-economy linkages within their boundaries.

Provincial and municipal governments with their regulatory agencies and the regional gas and electric generation and distribution agencies are the groups that will decide the success of district energy in Canada. Therefore, it is important to assess the manner in which local decision-making can be changed to ensure more cost-, environment-, and economy-effective energy planning and energy use for Canadian urban communities.

Given the:

- general lack of awareness with the costs and benefits of district energy;
- formidable capital requirements;
- the subscriber's need to feel confident in the technical and administrative capabilities of the district energy company,
- proven long-term planning capabilities; and
- access to long-term financing. There appears to be no entity other than an existing gas/electric/municipal utility that could assume near-term responsibility for a community integrated energy

> system. Even where a company had access to the capital required for a CIES, if the company does not have a time-proven record of energy delivery, it would not be acknowledged as a reliable supplier by potential subscribers.

The question is not really what party but rather how. How do we get the three different parties-electric utility, gas utility and municipality--together into going ahead with a CIES project? The answer appears to be to Canadianize the European community energy planning model and give Canadian municipalities responsibility for community integrated resource planning.

Who actually develops CIES projects is immaterial, though if European experience is any guide, it will come about under municipal auspices with federal and provincial government commitment to financial incentives and changes in regulation that favour CHP-based CIES systems. Some central government guidelines regarding IRP would also be expected together with some central government analytical assistance so that the municipality is better able to investigate the energy-environment-economy impacts of alternative community integrated resource plans. A commitment to look seriously at the feasibility of long-term contracts for government buildings and their correction to CIES networks is also warranted.

In the longer term, similar to European CIES development, the "district energy" company could examine "farming out" sub-components of the CIES system (e.g., long distance heat transmission) after district energy is more widely accepted by the public and the investment community (see Part II).

5.6.2 Electric Utilities

Increasing demands for electricity and the need to build new power plants and transmission lines is one of Canada's most critical problems for the future. Rapidly increasing demand for air conditioning, particularly in commercial buildings, is a key reason that electricity demand is growing. Electric utilities are increasingly being required to undertake internal Integrated Resource Planning to examine alternatives to simply building more power plants to meet Canada's electricity needs. Usually this means demand-side management--investment in energy efficiency in customer buildings and facilities.

Canadian electric utilities have not been active in promoting CHP with CIES because of the difficulty in incorporating CHP opportunities into long-term planning of energy generating capacity and because of the legal obligation to provide the most reliable and economic service to all customers. In short, their mandates usually do not encourage or authorize them to do so.

Existing attitudes to cogeneration appear to be a major obstacle--utilities, while they state that they are in favor of CHP, are not generally perceived to be the instruments to provide financial incentives to encourage cogeneration. It would appear that there is a role for governments to become involved in promoting and assisting in the development of CHP with promotion directed at municipal and utility levels.

Today, it is conceivable to view the establishment of CHP facilities, associated with an industrial or commercial complex, as an extension of the public utilities' recognized role of providing electric power. If CHP facilities could be financed at the lower interest rates now enjoyed by utilities, this would provide a strong incentive to the increased production and use of district energy.

Non-utility proponents of district energy systems will likely find themselves dealing with electric and natural gas utilities. In many cases, the CIES proponent may find utilities to be initially hostile toward the prospect of a new or expanded CIES.

For almost all district energy systems, electric utilities supply the small amounts of electricity required for the operation of the central plant and distribution networks. Also, when new buildings are constructed in the vicinity of a CIES, electricity may represent a competitive source of energy for heating and cooling.[13]

Three types of system developments may, however, add substantially to the complexity of the relationship between a district energy system and its electric utility:

- If the district energy system wishes to use cogeneration equipment, then the system must negotiate with the electric utility to establish the terms and conditions of the interconnection as well as the electric utility's buyback rate.

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[13] International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *District Energy Systems, Promotion Manual for System Developers and Operators*, Second Draft, November 1991.

- If the system seeks to introduce district cooling, it may have a major impact on the utility's peak load as well as energy sales volume.
- If the electric utility seeks to sell heat or cooling from a generating station, then the district energy system may become a large customer of the utility.

As a district energy system expands its subscriber network and adds cogeneration and/or district cooling capability, it may encounter some difficulty with the regional electric utility:

- Most utilities are strongly supply oriented and view moves to take away load or contribute to supply as undesirable competition.
- Many utilities are implementing programs to encourage a reduction in electricity demand (demand-side management--DSM) or investment in non-utility generation (NUG) projects. Ontario Hydro and the Ontario Ministry of Energy are good examples. However, virtually all of these programs do not incorporate a legitimate role for district energy as either a DSM technique, or as NUG, or as a sink for community heating and cooling and a pollution reduction strategy. As discussed in Section 5.9.2, this is not surprising as Ontario does not yet have an IRP process that could assess the relative energy-environment-economy benefits and tradeoffs of DSM, NUG and heat and electric power for its regions and communities.

What should be of particular interest to utility planners and energy departments is that district energy is a supply-side efficiency initiative. New high efficiency CHP and CIES technologies attack the energy efficiency problem from the supply-side rather than from the demand-side. Greater energy efficiency might be achieved faster and at less cost through CHP and CIES technologies than would be possible by focusing on demand-side efficiency measures alone. It may be more expedient and cost-effective to implement CIES than to rely on demand-side management programs, given the myriad of players and potential responses to DSM by consumers in the residential, commercial and industrial sectors. Many electric utilities are now finding that the benefits from DSM are not as great as once believed. Moreover, some DSM programs carry their own environmental impacts--impacts that are seldom accounted for by DSM proponents.[14]

Lower rates of return required on supply-side investments by gas and electric utilities, as compared to energy efficiency investments where companies and individuals demand paybacks of three years or less, also supports supply-side CIES projects. Moreover, with supply-side investments, such as CIES, there is no rebound effect to worry about as is the case with some DSM programs.

In summary, a major opportunity exists to promote the ways in which district energy can contribute to electric utility interests in demand-side management and non-utility generation. For example:

- CIES cogeneration systems would provide power coincident with winter electric peak demands. Also, on an emergency basis, CIES systems could provide power to meet summer peaks.
- District cooling systems could have a moderate to major impact on summer peak electrical loads. If steam absorption systems were substituted for electric chillers, the total chilling load would be removed. If central chillers were employed, these would offer greater efficiency than individual chillers, especially as the refrigerants that will replace CFCs will result in lower chiller efficiency or require chiller modification. With central chillers, the electric utility would find it easier to deal with problems of unexpectedly high summer peaks...the electric utility could arrange with the CIES to reduce its total electrical load gradually, thereby spreading the impact evenly among district energy subscribers.[15]
- Large utilities tend to be cumbersome in their decision-making processes. This characteristic is accentuated by new in-house organizational structures established to pursue DSM and NUG strategies. Difficulties are compounded as well by some duplication in legislation--e.g., the Ontario Environmental Assessment Board, the Ontario Energy Board and

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[14] Barbara D. Baker, *Demand-Side Management for Electricity: Pushing Back Barriers*, CERI Study No. 43 (Calgary, Alberta: Canadian Energy Research Institute, March 1992).

[15] International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *District Energy Systems, Promotion Manual for System Developers and Operators*, Second Draft, p. 39.

the Federal Environmental Review Agency approval process.

If efficiency-based standards come into play, then utilities might be able to sell heat and invest their money in district energy systems rather than expensive fluidized gas desulphurization scrubbers, NO_x control systems, etc. This would be an incentive for utilities to become more actively involved in CIES. Getting district energy off the ground and running requires a fundamental rethinking on the part of Canadian electric utilities. Rather than building large-capacity stations, smaller, more municipally-oriented combined heat and power stations connected to CIES might be a better way to go. Municipalities and utilities would then share a common interest, with the municipality acting as a radiator. The urban community substantially reduces its outflow of energy dollars and also reduces waste streams in the process. The large provincially-owned electric utility improves its public image by "going small" and showing real interest in how to best meet the needs of the community. Risk sharing of CIES production facilities would also benefit the present, non-utility-generator policy focus of some provincial governments. Rather than privatizing the large electric utility, this might be the best may to realize the inherent benefits of "large" utility and "small" NUG.

5.6.3 Gas Utilities

5.6.3.1 The Competition

District energy systems using natural gas as their thermal energy source find themselves as both a customer and competitor of the local gas company. Because district energy will often be a more efficient approach than the use of decentralized on-site boilers, less gas may be required to meet the thermal needs for the buildings served. Also, because of its volume, the CIES can often negotiate lower interruptible rates with its gas utility or buy directly from gas suppliers at the wellhead. Furthermore, with the capability to switch to heavy fuel oil and use numerous waste energy sources, the district energy network has the capability of displacing all of its gas purchases, if gas prices are uncompetitive. As a result, expansion of district energy system activity could result in a considerable reduction in the gas utility's profits.[16]

On the other hand, some natural gas distribution companies may see opportunities associated with CIES. If the district energy system is served on an interruptible rate basis, the gas company can add to its firm supply customer base without having to increase pipeline capacity. Also, growing concern over the greenhouse effect is leading to a preference for low CO_2 fuels. In many areas, urban cogeneration with natural gas will be preferred over all other energy sources because of its superior emissions characteristics.

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[16] Ibid., p. 37.

Dealings between district energy companies and natural gas utilities will typically be armslength, reflecting the competitive nature of the relationship. It is essential that CIES proponents identify specific opportunities where common interests exist with the gas distribution company. For example, the CIES capability to use large quantities of gas on an interruptible basis can increase the total volume of gas sold through the gas distribution network. These opportunities may be based on cogeneration or cooling that uses gas-fired thermal energy.[17]

5.6.3.2 Becoming "The Competition"

Canadian gas distribution companies (i.e., Consumers Gas and Union Gas) would be ideal district energy candidates, as electric utilities are hesitant to get into heat production and distribution. These gas companies are large, investor-accredited private companies that have easy access to the investment capital required for a CIES project. In addition, as private companies they could make full use of Class 34 capital cost allowances. Finally, they are proven, reliable suppliers of energy--an all important factor from the subscriber's point of view.

District energy could be used by gas distribution companies to expand sales in some areas and provide a means for gas to act as a demand-side management tool by displacing electrically-driven chillers. Gas utilities stand to look good in the public's eye as the move to CIES could be marketed as "just one way" the utilities are committed to reducing the environmental impacts resulting from Canadians' use of energy. Importantly, by pushing the "we all have a role to play" marketing campaign, the No In My Backyard (NIMBY) virus might be breached, allowing central business district siting for CIES plants.

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[17] Ibid., p. 38.

5.6.4 What About Municipalities?

5.6.4.1 The Lead Role

As described in Part II, probably the simplest and most cost-effective way of promoting CIES across Canada would be to delegate Integrated Resource Planning for heat and electricity to Canadian municipalities. It makes sense that municipalities take the lead role in CIES project implementation as they have in Europe and in the United States. District energy fits with municipal jurisdiction as municipalities are responsible for building codes, waste streams, planning for new commercial and industrial growth, and transportation services such as buses, light rapid transit and inner city parking.

As seen in Part II, delegating responsibility for energy planning to European municipalities is the single most important reason for the success of European district energy development and the attendant reduction in pollutants witnessed in many European countries.

As an alternative, the creation of a special unit within the municipal/provincial government, analogous to the P.E.I. Energy Corporation, that develops energy projects is a strategy that would promote CIES development. But, the complexity associated with planning for CIES requires that this municipal/provincial agency have a full-time commitment to district energy.

While municipalities across Canada are directly responsible for a myriad of factors that impact on energy use and the environment, there are few municipalities (outside Ontario's municipal electric utilities) involved in the production and distribution of energy. This stands in marked contrast to the type of detailed regional planning and rationalization of competing energy forms that has aided the development of European district energy.

While Canada's federal and provincial governments play lead roles in the energy sector, municipal governments--a driving force in European and U.S. CIES development--are generally excluded from Canada's energy sector. This is peculiarly at odds with the fact that Canadian municipalities are directly responsible for areas that have a major impact on energy end-use and the environment--i.e., rail, bus and road transportation systems; downtown parking; building codes; land use planning; waste management; water use; recycling programs; tree planting; and sewer, natural gas and electricity distribution lines.

As Canadian municipalities are responsible for sewer, water and other services requiring extensive piping and planning, it only makes sense that they be responsible for the planning and infrastructure for CIES. Further, municipal projects such as waste incinerators can be made more cost-effective if they also generate energy for the community. To gain the benefits of CIES, a variety of disciplines at the municipal government level must become more actively involved in community energy planning. Active support from the regional, provincial and federal governments is also important to CIES implementation, as is the input of regional heat and gas utilities. This sharing of responsibility is particularly important across Canada where municipalities are being called upon to do more and more with less tax dollars.

Municipalities should get involved because they are using a variety of energy forms separately and if they can combine them, they can get a substantial reduction in CO_2 and other emissions. It also represents a large reduction in cash flow out of the community, a factor that is often overlooked. CIES may be viewed by a municipality as part of the solution to a municipal solid waste problem, or a method of encouraging urban renewal or attracting industry by exploiting a local low-cost energy source.[18]

Municipal governments also possess those attributes required to overcome many of the institutional barriers to district energy. In common with Canada's gas and electric utilities, most municipalities are experienced in long range planning, normally have reasonable access to capital, and have less demanding rate-of-return investment objectives than the private sector. Through the operation of normal services, such as water distribution and sewage systems, many municipalities have already developed the skills and resources necessary to operate a district energy system.

The role of Canadian municipal governments in the energy sector has, with some notable exceptions, been somewhat modest. If district energy is to develop in Canada, federal and provincial governments must create an awareness of district energy and the direct and indirect benefits that this technology offers to Canadian municipalities. The objective of an information program would be to encourage municipalities to assume, as they have in other countries, a leadership role in the promotion and development of CIES technology. Without the active and enthusiastic support of municipal governments, it is unlikely that district energy could achieve the level of market penetration necessary to make it economic.[19]

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[18] Monenco Consultants Limited, DHM Energy Consults Ltd., K-Konsult, and Cogeneration Associates Limited, *The Realistic Potential for District Heating in Canada, Volume I*, April 1985, p. 44.

Municipalities should assess development of long-term energy plans on a basis similar to the regional and municipal energy planning that is carried out in many European countries. Such plans could be used to ensure that individual low-grade fuel energy projects within the community were set up in such a manner that they could ultimately be connected and integrated into a single multiple-source heat system.[20]

5.6.4.2 Analogy to Historical Electricity Development

Future prospects for the development of CIES in Canada will depend on the ability of the technology to compete economically with existing energy forms. Alternatively, new approaches to community energy planning must evolve to push decision-making down to the community and municipal government level.

The development of a municipally-operated district energy system is analogous to the historical development of centralized electricity generation in Canada. District energy offers all the benefits proffered for government electricity monopolies established in Canada. Moreover, given the increasing cost of centrally-supplied electricity generation and more stringent environmental controls, CIES offers a means of rationalizing community energy heating and cooling with the added benefit of providing electricity to the regional electricity grid from dispersed non-utility CIES generation stations. This could greatly reduce the environmental impacts of energy production and use.

District energy also makes use of high urban densities as a community resource, can use community fuels such as refuse, and reduces transmission capacity constraints as it reduces demand on regional transmission and distribution lines. All of these attributes seem particularly important and applicable to jurisdictions actively supporting parallel generation, such as Ontario.

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[19] Ibid., p. 49.
[20] Ibid., p. 49.

In many respects, CIES is the perfect match for cities like Toronto and Ottawa that have Public Service Commissions in place to facilitate district energy, the need to revitalize the downtown core, the responsibility for urban planning, an apparent public directive to minimize the environmental impacts of energy production and end use, and large commercial space occupied by federal, provincial and municipal civil servants.

While many of Canada's largest, provincially-owned electric utilities increasingly favour cogeneration to a greater or lesser degree, many of Canada's smaller, municipal utilities do not appreciate the potential community benefits of regionally-dispersed, district energy systems. This is an area that requires proactive initiatives by both federal and provincial government departments--i.e., the Ontario Ministry of Energy; Energy, Mines and Resources Canada; Toronto Department of Public Works and Environment. Responsible non-government organizations should also be involved to overcome the NIMBY virus.

Involvement of municipalities in generating electricity is a big step in terms of capital cost and risk. However, Ontario Hydro could work with municipalities to develop district energy systems by helping to finance the capital cost of the station, with the municipality possibly picking up the heating side. Alternatively, the private sector might play a role by developing the CHP plant and allowing the city to pick up responsibility for the heating side. The electricity could then be sold to Ontario Hydro or directly to the municipal electric utility.

Many municipalities are constrained from investing in CIES as they lack access to the capital required to finance these systems. Indeed, in many jurisdictions, municipalities suffer from under investment in their current infrastructure (i.e., water and sewer), such that there is a reluctance to take on the capital burden of an additional service. In most Canadian communities, ratepayers have reached the limits of their tolerance levels with taxes by all levels of government and will strongly resist increases.

On the other hand, where municipalities have to replace existing infrastructure, the cost of constructing district energy distribution lines may not be great. In new developments, the piping would be presumably be put in place by the developer, so that the district energy company would not have to bear the cost of the piping. Just like putting in a gas line, or a sewer or water line, the district energy system costs are paid by the developer along with roads and lights.

Municipal governments with provincial/federal government support could amortize the large upfront capital costs necessary to get many of these projects off the ground. Municipalities would become non-utility generators of heat and electricity to satisfy increasing demand for low emission, dispersed electric power and minimize heat loss and maximize long-term benefits to the community.

To promote Integrated Resource Planning, municipal utilities in Ontario that simply distribute electric power will have to enter the business of electricity-heat production and distribution. They will need considerable support from federal and provincial agencies in the energy, environment and economy planning areas if they are to undertake this new responsibility. Unless there is a clear mandate directing municipalities to encourage them to enter into community Integrated Resource Planning, it is unlikely that they will do so.

5.7 Coherent Government Programs

To ensure the success of programs designed to promote greater awareness of district energy, it is important that information be presented in a coherent manner. Unfortunately, the various levels of government in Canada--municipal, regional, provincial and federal--make it difficult to coordinate programs for the adoption of more energy efficient technologies.

Many firms report frustration with government programs designed to encourage the adoption of more energy efficient technologies. Industries frequently lack clear information concerning program objectives, criteria for eligibility, means of application and potential net savings. These are the principal reasons why industry advocates the use of fiscal measures such as tax incentives rather than specific grants and other closely-administered government programs.

To rectify this, the federal and provincial governments, in consultation with business and industry, should undertake a detailed examination of energy efficiency programs to increase program utility and accessibility. Following this appraisal, federal, provincial and municipal regulations should be changed if they present barriers to CIES project development.

5.8 Training Canadian CIES Specialists

Given its rudimentary position in Canada's current energy mix, it is not surprising that an important obstacle to CIES development is a shortage of skilled Canadian personnel. There is a need for Canadian planners, engineers and architects to become more aware of new technologies, options and costs associated with district heating and cooling. Engineers, designers, system operators, maintenance personnel and other professionals who can design, construct and operate district energy technologies and processes are required.

Builders and their tradespeople have little understanding of CIES and Canadian engineering firms and consultants are unfamiliar with European state-of-the-art hot water systems. To overcome this, federal, provincial and municipal governments should work together to support the training of the full range of specialists needed to design, construct and maintain Canadian CIES projects. **Review of Scandinavian CIES training programs would be a useful starting point.**

5.9 CIES Incentive Programs

Potential customers are hesitant to commit to long-term contracts for thermal energy without knowing details of delivered cost and operating reliability. Reluctance to invest in CIES is further exacerbated as district energy systems require large capital outlays and long payback periods. These barriers cannot be resolved without broad-based government policies that recognize the cost and energy efficiencies of CIES.

As industries tend to invest to increase production in preference to projects aimed at improving energy efficiency, governments should consider subsidies on CIES project interest rates and other incentives that will accelerate the adoption of technologies and processes that are in the national interest. These would result in greater investment in energy efficiency than is presently the case which is based upon grants and accelerated capital cost allowances that characterize existing federal incentive programs.

Renters and the government/institution sector require special attention because programs and customer incentives must be expressly tailored to them to ensure their participation. The government/institution sector faces problems in that gaining internal capital can be extremely time consuming. The decision-making process in this sector slows investment choices to the point of being impossible in some cases.

5.9.1 The Ownership Dilemma

Building owners are not interested in the most energy efficient system but the one with the smallest capital outlay. A major investment barrier is that the person who makes the investment is not the one who receives the benefits, except for owner-occupied buildings. Tenants who pay their own utility bills but do not own the equipment are hard to reach because they are reluctant to invest in measures that they cannot take with them when their lease ends. The tenant generally does not differentiate product offerings on the basis of energy cost for while energy costs may be substantial in total, they are usually less than one percent of total business expenses or less than three percent of lease cost.

One means of overcoming the ownership problem would be to set up a district energy system and give the savings to the building owner so that he/she gets paid for installing a more energy- and cost-effective system. Monthly tenant bills could continue to be based on tenant consumption and the old billing rate, but the building owner would receive a rebate from the CIES company based on building consumption multiplied by the old rate less consumption multiplied by the new rate. After payback, all billing rates in the building would be based on the actual cost of providing hot water. The building owner would be able to use district energy as a marketing technique to entice new tenants to the building by showing energy costs that are lower than comparable buildings in the region.

The district energy utility wins by reducing emissions and potentially selling electricity to the regional electric utility; the building owner wins by getting a rebate on energy consumption; and the tenants win because they are paying no more than what they would have under the old heating system while helping to reduce emissions, improve regional aesthetics and contribute to regional employment. The heat (gas) utility wins in that it improves its overall energy efficiency, reduces environmental impacts and adds new capital to rate base, thereby improving shareholder interest in the utility, which in turn helps to keep the cost of capital at acceptable levels.

5.9.2 Financial Incentives and Risk Sharing

A major criterion in investment decisions is the initial cost of an investment. Recent surveys have shown that for commercial and industrial customers, payback must be under two years, and that payback under one year will improve market penetration considerably. People also fear the uncertainties involved in new technologies. If the district energy utility/government can reduce this fear directly or indirectly, it can positively influence customer behavior in favour of CIES.

Customers are concerned with the upfront cost of the measure and how long it will take the measure to pay for itself in energy savings. The financial concerns are over how to pay for the measure--will they have to borrow or will they be able to free up their own money? Customers also wonder about the riskiness of the investment--what if the measure does not provide the projected savings, resulting in a lower or reduced return on investment? Consequently, it is important for the district energy utility and government to design customer financial incentives that mitigate these barriers to CIES investment.

Surveys show that risk sharing by the utility and the consumer makes a large difference to the acceptance of energy efficiency program(s). Reduction of uncertainty about reliability and performance of the measures is valued by all sectors. Shared savings programs offer not only risk reduction but also reductions in payback time and capital costs.[21]

There are basically four types of customer financial incentives--loans/leasing, subsidies/rebates, direct installation, and shared/guaranteed savings. Each offers a different solution to market penetration. Loan incentives offer loans to customers at or below current market interest rates. They are provided by banks, third-party lenders or the utility itself. The goal is to ease the capital burden of the energy-saving measure either by lowering the cost of borrowing or by making loans more accessible.

Although these incentives target financial barriers, they also reduce a customer's perceived risk by reducing the potential downside investment impacts relative to other investments. Leasing programs reduce upfront capital requirements and may reduce the customers maintenance responsibilities. Smaller customers, low income customers and the government/institution sectors are more likely to use these incentives because their access to capital is limited. For government/institution consumers, the funding may be available internally but hard to obtain, while low income customers may not have access to loans at all.

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[21] MSB Energy Associates, Inc., "Report on Gas Integrated Resource Planning," prepared for Ontario Energy Board, June 10, 1991.

Subsidies or rebates are cash payments made to customers. These incentives aim at increasing the profitability of the measure to the customer by reducing the payback period. Subsidies and rebates need to be set at a level high enough to reduce payback to below one to two years, must be easy to obtain (i.e., not too much paperwork), and must be flexible enough to meet individual customer requirements.

Direct installation incentives are arrangements set up by the utility to have equipment installed for a reduced fee or free of charge. Utilities may install the equipment themselves or arrange for a contractor to do it. These incentives reduce customer risk as the customer is not faced with an overwhelming amount of information and is guaranteed of product quality because the utility has a stake in the measure. The utility covers some or all of the cost of design and construction and guarantees either the payback or the system performance.

In a shared savings program, the utility arranges and pays for the installation of the measure and retains a portion of the resultant savings. The customers monthly bills are adjusted to reflect a portion but not all of the total savings, thereby allowing the customer to pay back the utility slowly while also receiving bill reductions. A related program is performance contracting. Here a third party contractor installs the equipment and then receives part of the customer's energy savings. The contractor retains ownership of the equipment and may also provide maintenance, depending on the term of the agreement. The utility plays a match-making role by linking contractors with customers.

These incentives are gaining favor because they address the risk question directly and generate immediate benefits for all involved. Shared savings programs offer not only risk reduction but also reductions in payback period and capital costs.[22]

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[22] Ibid.

5.9.3 Subsidies and Tax Credits

Owing to the capital cost of the distribution piping associated with CIES, taxation can be a major financial issue. One device to minimize the tax burden is to provide a tax credit for any expenditures directed to greater energy efficiency, subject to previously established program criteria. For example, a straightforward tax credit for investments in CIES plant and distribution could be implemented. Alternatively, a credit to building owners for the costs of connecting to a CIES would help to induce growth in the customer base. To bring down the cost of CHP, a sliding tax credit could be provided for an electric generating plant with an efficiency above a baseline level, with the credit increasing based on overall efficiency. To raise revenues for the credits, a tax penalty could be applied to new low efficiency plants.[23]

A tax credit or subsidized interest rates would be an appropriate near-term mechanism for encouraging CIES until energy-environment-economy planning and regulations are revised to better account for our evolving understanding of the environmental externalities associated with Canadians' energy use.

Another incentive would be to subsidize low interest loans for energy efficiency projects meeting specified criteria. Federal and provincial government(s) could accelerate CIES by subsidizing project financing such that CIES projects enjoyed the lower interest rates now received by regulated Canadian electric and gas utilities.

Canadian banks, trust companies and pension funds could extend such loans, providing that the difference between the rates they offer for CIES projects and commercial rates for other loans is financed by government subsidy. These investments would be a better risk than many bank loans to developing countries and would support the Green Theme--"Lets All Work Together To Clean Up The Canadian Environment"--literature prominently displayed in many Canadian banks and trust companies.

Other measures facilitating the financing of district energy systems include establishment of a revolving fund for financing new or expanded CHP systems, that would generate additional funds as development takes place and the borrowers repay the fund.[24]

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[23] Mark Spurr, *Public Policies for Encouraging District Heating and Cooling*, International District Heating and Cooling Association San Francisco Annual Meeting, June 24, 1991.

5.9.4 Breadth of Incentive Programs

5.9.4.1 CIES Investors

To accelerate the adoption of energy efficient measures in the residential and commercial sectors, interim financial incentives are needed. These should be in the form of interest free or low interest loans, to assist builders and developers (in the case of new buildings) and owners (for existing buildings) to offset capital costs. These incentives should be offered for a period sufficient to demonstrate the advantages of adopting district energy and to train designers, tradespeople, inspectors and construction personnel. The period will also allow time to determine recommended energy performance levels.

Adopting and recording the performance of district energy demonstrations would, with time, make it possible to effectively predict the financial return to the investor. Where CIES projects lead to major savings, programs financially assisting the demonstration of their benefits would encourage their widespread adoption.

Financial assistance from the government is necessary for developers of CIES if high market penetration levels are to be achieved. This assistance could include:

- financial and analytical support (e.g., HEATMAP) for district energy feasibility studies, particularly for cities and towns having the attributes likely to favor district heating;[25]
- favorable tax treatment of private investment in district energy distribution and end-use systems; and
- assistance in project financing, both through grants and provision of low interest loans.[26]

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[24] Ibid.

[25] See Appendix D for a description of the HEATMAP software.

[26] Monenco Consultants Limited, DHM Energy Consults Ltd., K-Konsult, and Cogeneration Associates Limited, *The Realistic Potential for District Heating in Canada, Volume I*, April 1985, p. 50.

The federal government could provide financial incentives to encourage and assist industry to adopt energy efficiency technologies. Financial assistance from government is necessary for developers and subscribers of CIES if high market penetration levels are to be achieved. Due to the number, diversity and particular needs of Canadian business and industry, incentives need to be varied enough to provide a choice of alternatives.

Some of the following programs could be made available so that companies can select the one that best suits their needs:

- retain the present accelerated write-off for capital expenditures on specified energy efficiency technologies listed in Class 34 of the Income Tax Regulations;
- provide the option of a one-time refundable tax credit, administered through the income tax system, for capital expenditures on approved energy efficiency technologies;
- provide the option of subsidized loans at preferential interest rates, to be offered through Canadian lending institutions, for investment in approved energy efficiency technologies;
- allow municipalities to pass applicable Class 34 savings on to their customers and private co-investors;
- provide financial and analytical support for CIES feasibility studies, particularly for cities and towns having the attributes likely to favor CIES; and
- implement favorable tax treatment for private investment in district energy distribution and end-use systems.

5.9.4.2 CIES Customers

Financial assistance is also required to help the subscriber deal with the cost of retrofitting existing building stock to district energy and thereby ensure maximum market penetration. This assistance, provided either directly by government and/or indirectly through the district energy developer, could take the form of:

- favourable tax treatment of investment in subscriber systems;
- grants to offset the cost of retrofit;

- low interest loans, with repayment schedules related to the savings in energy costs. The objective of such loans could be that the total cost of district energy to the subscriber, including loan amortization, would not exceed his cost of heating with his existing system;
- tax incentives to encourage inclusion of central heating/cooling systems in new development (investment tax audits, depreciation, etc.); and
- explicit inclusion in the rate base of resource recovery capital costs and construction work in progress for CIES projects.

5.9.4.3 Putting CIES on a Level Playing Field

Going beyond purely financial perspectives, CIES advocates also assert that the following are required to put district energy on a level playing field:

- ensure that full consideration is given to connecting federal, provincial, territorial, regional and municipal government buildings to community integrated energy systems.
- conduct a comprehensive assessment of the potential contribution of district energy to energy efficiency, energy-environment-economy improvements and controlling increases in demand for electricity.
- evaluate a variety of policy options, including mechanisms for recognizing the environmental benefits of district energy, encouraging CIES through tax policy, regulation, and other measures.
- educate the provinces, municipalities and the public about CIES and its benefits, and assist them in integrating district energy into their community planning.
- increase federal government research and development of advanced district heating and cooling technologies and demonstrate these technologies in Canadian urban communities.
- make Canadian municipalities responsible for energy planning in their jurisdictions as many Scandinavian countries have done to support CIES development (see Part II).

Table 5.1 shows various examples of government policies and programs supporting district energy development.

5.10 Improving Awareness

There is a great need to improve awareness of district energy technology and its benefits across a broad cross-section of the Canadian public--i.e., government officials, universities and community colleges, engineering consultants, environmental organizations, municipal politicians.

District energy's low profile has made it difficult to convince industry and government decision-makers that it is an important technology for improving energy efficiency and for reducing all of the environmental impacts resulting from energy use by Canadians.

Getting the general Canadian public and non-government organizations (NGOs) to fully appreciate community integrated energy is essential if we are to effectively neutralize the Not In My Back Yard virus and realize the many benefits for Canadian urban communities.

Convincing consulting engineers of CIES benefits and of all the costs of competing systems is a prerequisite, as this group greatly influences building owners' decisions. Costs often unaccounted for but important in the comparison of district energy and competing systems include: costs for storage tanks, flues, administrative costs for purchasing oil or gas as a primary or backup fuel, structural costs necessary to accommodate heavy mechanical equipment, property taxes attributable to boilers or chillers, and insurance and various other indirect costs that often are not included in the comparison. For example, on-site building boiler efficiencies that range over the year from 35 to 70 percent--a factor that can multiply the building's actual cost of heat from natural gas upwards considerably[27]--is very often not accounted for. Where possible, district energy subscribers must also be encouraged to base their heat supply decisions on life cycle costs rather than on low capital costs or short-term payback periods.

To the extent that credible economic analysis supports the development of CIES and that innovative financing and energy pricing can be developed, the problem becomes one of effectively disseminating

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[27] U.S. Department of Housing and Urban Development, "Energy in Housing and Community Development," report of the HUD/DOE Sixth National Conference on Community Energy Systems, Washington, D.C., January 19-20, 1988.

TABLE 5.1

GOVERNMENT POLICIES AND PROGRAMS SUPPORTING CIES DEVELOPMENT

Country	Regulation	Economic Instruments	Information/Consultation
Finland	Environmental regulations support CIES	Subsidies for CIES connection (1970s) Contribute to joint R&D program	Encourage acceptance of district energy
Denmark	Mandatory energy plans support CIES	15 percent incentives for CIES based on certain fuels (e.g., straw)	
	Prescriptive technology (natural gas replacing coal)	CO_2 tax	
Sweden		Subsidies for CIES systems (1982-84) Subsidies for certain new technologies (e.g., bioenergy) for CIES and other applications	
Germany		Financial support for R&D and, earlier, use of German coal	Some consultative activity
USA	Environmental regulations (e.g., Clean Air Act) indirectly support CIES	Tax incentives for certain energy sources (especially 1980s) for CIES and other applications	
		Financial support for feasibility studies and demonstration projects	
Canada		Tax incentives for certain energy sources for CIES and other applications	Information dissemination
		Limited financial support for feasibility studies and demonstration projects	

SOURCES: (1) International Energy Agency, *District Energy Systems, Promotional Manual for System Developers and Operators*, Second Draft for Experts Group Review, 1991; and, (2) Canadian Energy Research Institute.

CIES benefits to potential subscribers. This is a marketing problem. The forthcoming International Energy Agency's (IEA) District Energy Promotional Manual offers several useful insights into how this could be accomplished. It recommends various marketing strategies that can be used for developing full-scale marketing programs targeted at district energy stakeholder groups.[28]

5.10.1 Broad-based Marketing

For district energy to gain acceptance in Canada's competitive space heating market, potential subscribers (i.e., tenants and building owners) must be confident in this technology. To gain acceptance of building owners, CIES developers must show them system advantages, including reliability, long-term availability, reduced maintenance and operating cost and lower on-site capital costs. The developer must create confidence that it has the technical and financial resources to develop a stable fuel source, together with an operating system and organizational structure capable of producing and delivering thermal energy with a level of convenience and reliability exceeding that of traditional, individually-owned and operated on-site systems.

The most effective method of informing the public is through comprehensive programs designed and implemented by marketing specialists. General information programs seek to persuade customers to increase the efficiency with that they use energy. This approach is aimed at helping overcome the barrier of inadequate information as a hindrance to efficient energy use. These programs reach large masses of people with a fairly small budget. While coverage is broad, the depth of information offered by these programs is, by necessity, very limited.

Vehicles used for general information programs include brochures, direct mailings, bill inserts, clearinghouses, point-of-purchase advertising, mass media advertising, audio visual tapes, shopping center displays, speaker bureaus, and workshops and seminars. A draw back to these programs is that it is difficult to assess their effectiveness. On the other hand, informational programs can play a meaningful role, especially when combined with other delivery mechanisms.[29]

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[28] International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *District Energy Systems, Promotion Manual for System Developers and Operators*, Second Draft, November 1991.

More specific, personalized information can be provided to the energy user via the technical assistance delivery mechanism. Compared with the general information approach, this method requires greater involvement and expertise by the utility or the expense of contracting with vendors to supply these services. For the industrial sector, an audit is almost always site-specific and can cost in excess of $50 000. The technical assistance approach, however, is more likely to result in the adoption of energy efficient measures than the general information approach used in isolation. This personalized face-to-face approach is very effective, especially if financial incentives are offered to the customer at the same time. The barrier of inadequate information is targeted by direct customer contact, and the barriers of upfront costs and risks of energy saving measures are the targets of the financial incentives.

Another delivery mechanism utilities can use is joint programs with trade allies--appliance dealers, heating, ventilation and cooling (HVAC) contractors, architects and engineers. Joint education or advertising programs can be conducted, and/or the utility can train and certify the allies in energy efficiency methods and technologies. Utilities and their trade allies typically have strong networks. Programs that allow trade allies to use financial incentives available from the utility as a marketing tool can also be very useful. Informational programs that are not combined with financial incentives, on the other hand, may be of limited effectiveness.[30]

5.10.2 Marketing Demonstrated Benefits

To date, insufficient effort has been directed to developing projects that would demonstrate the present day costs and benefits of CHP-based district energy. Lacking this information, individuals, municipalities and companies will defer investment, if they believe they may be premature, ineffective, unsafe, or too costly for the potential savings they yield.

To overcome this important barrier, the federal government in consultation with provincial and municipal government, and gas and electric utilities should pursue several projects to demonstrate the many benefits of district energy technology. Central governments could help by financially supporting CIES feasibility studies that assess the benefits to urban communities of district heating and cooling systems. In this regard, HEATMAP, a computer software program that analyses site-specific district energy economics for Canadian communities could help greatly and should be made available to all interested parties--i.e., energy research institutes, engineering schools at universities and community colleges, and municipal planning departments (see Appendix D).

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[29] MSB Energy Associates, Inc., *Report on Gas Integrated Resource Planning*, prepared for Ontario Energy Board, June 10, 1991.

[30] Ibid.

Broad-based marketing directed to all potential CIES stakeholders is required on the outcome of these demonstration projects. Reference is again made to the marketing strategies discussed in the forthcoming IEA District Energy Promotional Manual.

While many of Canada's large, provincially-owned electric utilities increasingly favour cogeneration, many of Canada's municipal utilities and municipal planners do not appreciate the potential community benefits of regionally-dispersed, CIES networks. This is another area that requires co-ordinated, proactive initiatives by such groups as the:

- Ontario Ministries of Energy, Transportation and Communications, Treasury and Economics;
- Toronto Department of Public Works and Environment;
- Energy, Mines and Resources Canada, Industry, Science and Technology Canada and Environment Canada; and
- the Canadian Energy Research Institute (CERI), the Canadian Urban Institute and the Federation of Canadian Municipalities.

CERI is actively involved in research into how best to marshall Canada's limited resources to resolve energy-environment-economy issues of concern to all Canadians. For example, CERI's current program includes studies such as this one on community integrated energy, as well as:

- a major evaluation for Saskatchewan, Alberta, British Columbia and the Northwest Territories of least-cost strategies for greenhouse gas mitigation using models that have been developed by CERI and the Alberta Research Council over the last five years;

- demand-side management programs for electric and natural gas utilities; and
- research on alternative transportation fuels and electric vehicles.

Following publication, Canadian Energy Research Institute staff arrange conferences and seminars across Canada that allow interested parties an opportunity to question CERI staff and other industry and government experts on topical energy issues. The Institute sponsored, for example, an alternative transportation fuels conference in Ottawa in April 1992.[31]

While district energy proponents assert that municipalities need a better understanding of district energy systems so that they are more fairly evaluated relative to competing energy supply systems, this point is equally applicable to provincial governments. On March 12, 1991 the Province of Ontario announced that it will restrict the use of electricity in non-profit housing. Until this announcement, government-assisted social housing had placed an emphasis on the lowest, first-cost. This has meant that electric heating is now used in over 80 percent of non-profit residential buildings. The Ontario Government is also examining the feasibility of converting even older public sector housing to natural gas, 80 percent of which is now electrically heated. While this is positive news for the gas industry, it appears that this policy switch was flipped without consideration of an even better way to save electricity and produce heat--district energy. While the Ontario Government's policy objectives of improving energy efficiency and reducing the demand for electricity are laudable, district heating would provide a far better long-term optimization of both heat and electric power than the simple move from electric to gas heating.[32] This action again stresses the need for Integrated Resource Planning where both heat and electric power are jointly planned for in Canadian urban and regional settings.

Correcting misperceptions is very important as engineers and others may hold the incorrect belief that the principal heat source for a district energy system must be within a few kilometers of the heat load. This misperception should be corrected by the communication of credible evidence that thermal energy can be cost effectively transported through hot water piping for distances of over 20 kilometers. Representative costs for district heating and cooling systems and the application of HEATMAP for various test cases might also be provided to consulting engineers and provincial and municipal energy planning departments (see Appendix D). Descriptions of successful systems, such as those in Charlottetown, Prince Edward Island, Malmo, Sweden, Copenhagen, Denmark, and St. Paul, Minnesota can increase the level of confidence that CIES is a proven, low-risk approach to community energy needs (see Part II).

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[31] Call CERI at (403) 282-1231 for additional detail on publications and conferences.

[32] Discussion paper on *Demand Side Management in Canada's Natural Gas Industry* (February 27, 1991), p. 1.

The challenge facing district energy system proponents is to gain the maximum possible level of support from the many firms, organizations and individuals that can influence CIES projects. Figure 5.2 portrays the various stakeholder interests that have an impact on district energy planning and operations. It is also necessary to neutralize potential opposition from those who feel their interests are threatened by district energy projects.[33]

5.10.3 Promoting to Customers

5.10.3.1 Promotional Planning

Building owners must be convinced that connection to a district energy system is preferable to the use of individual, on-site building heating and cooling systems. Since district energy systems do not typically offer dramatic cost savings to a building owner, promotional activities must be carefully planned in order to communicate the full range of benefits in a persuasive manner.

To establish a clear target for promotion activities, it is useful to understand how customers make decisions to connect to district energy. Figure 5.3 shows the steps involved in the customer decision process. These steps begin with the customer's initial awareness of district energy systems and continue to the detailed evaluation of district energy in comparison to individual building systems. The

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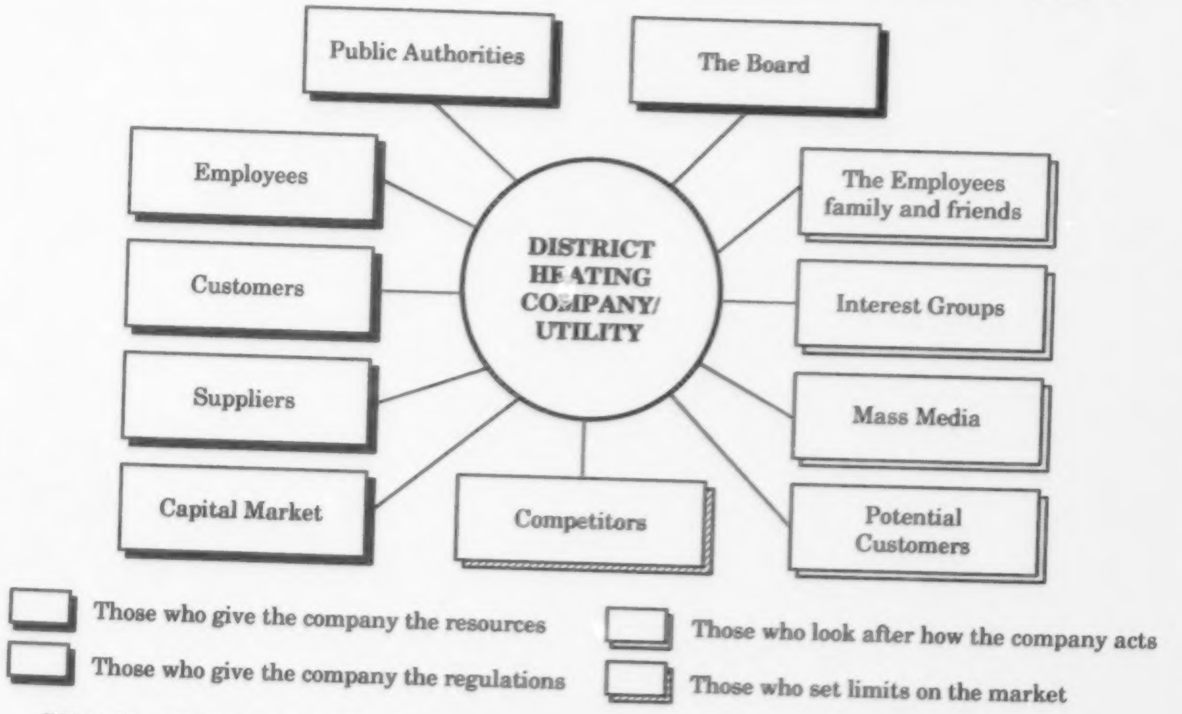
[33] International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *District Energy Systems, Promotion Manual for System Developers and Operators*, Second Draft, November 1991, p. 20.

FIGURE 5.2

THE WORLD AROUND THE DISTRICT HEATING COMPANY/UTILITY


Public Authorities
The Board
Employees
Customers
Suppliers
Capital Market
DISTRICT HEATING COMPANY/ UTILITY
The Employees family and friends
Interest Groups
Mass Media
Potential Customers
Competitors
Those who give the company the resources
Those who give the company the regulations
Those who look after how the company acts
Those who set limits on the market

SOURCE: Swedish District Heating Association in International Energy Agency, *Promotional Manual for System Developers and Operators*, *Draft*, 1991.

FIGURE 5.3
CIES CUSTOMER DECISION STEPS

Steps in the Decision Process	Issues for Promotion
Awareness and Interest	• Is the customer aware of CIES as an option? • Is the customer interested in learning more about CIES?
Evaluation	• Is the customer familiar with all technology options which CIES may offer? • Is the customer considering all the relevant factors besides direct energy costs? • Is the customer using accurate information in the comparison of CIES with individual building systems?
Decision	• Who influences the building owner? (e.g., property manager? engineers?) • Are they aware? Interested? Able to make reasonable evaluations? • Who makes recommendations? Who makes the final decision? (e.g., senior official or board)
Implementation	• Who is the liaison with the CIES company during project implementation? • Are all questions and concerns promptly addressed?
Review and Reinforcement	• Is the customer satisfied with the CIES service (e.g., cost, reliability, service, administration)? • Is the customer considering a change (e.g., building renovation/expansion)? • Does the customer have new operating or property managers on staff who are not familiar with CIES?

SOURCE: International Energy Agency, *Promotional Manual for System Developers and Operators, Draft* (1991).

point of decision is followed by project implementation and an ongoing review of satisfaction with the decision.

It cannot be assumed that all customers are at the same stage in the decision process. For example, if it is found that customers or their consulting engineers lack awareness of district energy systems, promotional information can be provided to them and personal meetings arranged to discuss the economics as well as community, tenant and building owner benefits of CIES networks.

To convince potential subscribers to connect, the CIES proponent must assemble the full range of financial and operating advantages of district energy. None of the criteria assessed by potential subscribers is more important than financial attractiveness--comparison of the financial returns from district energy compared to decentralized on-site options. Consulting engineers tend to be skeptical of CIES advantages as they are unfamiliar with CIES networks. For new building designs, they may not have sample drawings of connections to district energy systems readily available from other projects whereas it is easy for them to prepare drawings for "packaged" boilers and chillers used in on-site building heating systems. As a result, estimates prepared by CIES proponents may not agree with those prepared by the subscriber's consulting engineers, who may use "rules of thumb" that are not based on current state-of-the-art CIES cost and performance factors.

The recently published International Energy Agency report on the conversion of existing heating and cooling systems to district energy would assist preparation of cost effective CIES connection plans. Use of the forthcoming Canadian version of Washington State Energy's **HEATMAP** software would also be of major assistance in system comparisons.

5.10.3.2 Adding Other Benefits to Financial Comparisons

While financial attractiveness tends to be the most important consideration, potential subscribers may be swayed in their evaluation by other tangible CIES benefits. These benefits should be clearly presented to prospective customers and the public alike as it will be easier to "sell" the CIES concept to building owners if the public believes CIES technology to be a cost-effective solution to the environmental problems faced by Canadian urban communities. The Green Theme marketing promotions used by supermarkets, trust companies and gas stations, to name but a few, is telling evidence of how these companies are attempting to link their products and services with "the environmentally better" philosophy.

Added benefits of CIES include:

- convenience to property managers through reduced maintenance requirements for energy systems;
- long-term security of an economical energy supply through flexibility of the central heating plant in using alternative fuels and energy sources;
- the removal of concerns regarding future regulations of emissions, stacks and other environmentally sensitive factors as these responsibilities are taken over by the CIES;
- potential for the long-term, least-cost energy supply since district energy is able to switch to the lowest-cost energy source (e.g., heavy fuel oil vs. natural gas at interruptible rates) and waste energy supply (e.g., industrial waste heat, cogenerated heat or incineration of municipal wastes);
- greater cost effectiveness in meeting emissions and other environmental regulations;
- greater reliability of supply of thermal energy with district energy through greater redundancy of capacity, flexibility of fuels used and rigorous maintenance procedures; and,
- greater comfort of building occupants.[34]

5.10.3.3 Cooling Options

Though few district energy systems in Canada outside of the CIES project planned for Edmonton, Alberta provide cooling, the demand for CIES-based cooling could grow as building owners examine ways to meet chilled water requirements. This assessment has taken on some urgency as the federal government has committed Canada to the elimination of CFC production by 1995, due to its ozone depleting properties. Adding cooling to a district energy network can dramatically improve project economics, as CIES costs can be spread over a larger customer base.[35]

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[34] Ibid., p. 26.

5.11 Promotion for Municipal Systems

5.11.1 Interest Groups

The interests of many groups in the community are affected by district energy projects. Consequently, the development of CIES projects is usually a time consuming challenge.[36]

Figure 5.4 outlines the steps involved in a CIES project--from the initial idea through to project implementation. Where government programs are supportive of district energy and where it is well understood, a period of four to five years will typically be needed for the CIES concept to translate into an actual working system. On the other hand, where government programs are not supportive and where district energy is not well understood, ten to fifteen years could be required to familiarize groups with the CIES approach, overcome opposition from entrenched interests and gain credibility from the local community.[37]

Municipal governments can relate to CIES in several ways:

- the municipal government may own the system directly or control a non-profit company that owns the system;
- municipal buildings may be connected as subscribers;
- construction permits are issued by the municipality;
- economic development departments may support the construction activity, the strengthening of the urban core and the substitution of "imported" fuel with locally available energy sources;
- traffic may be disrupted during construction;

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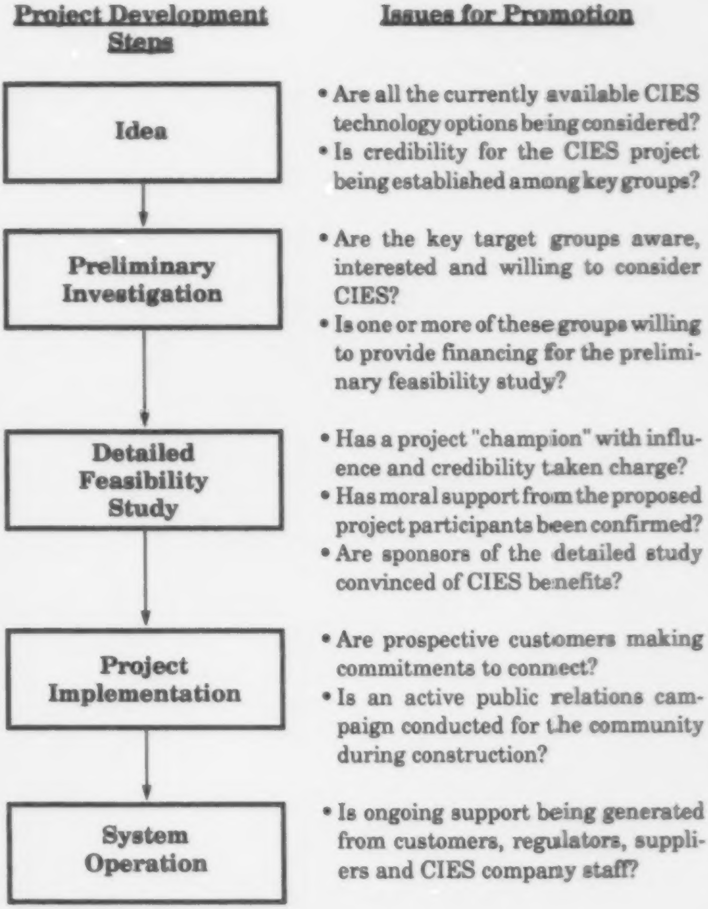
[35] See the discussion of Deep Lake Water Cooling in Toronto presented in Volume II.

[36] See, for example, the discussion of district energy in Toronto, Ontario presented in Volume II.

[37] International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *District Energy Systems, Promotion Manual for System Developers and Operators*, Second Draft, November 1991, p. 27.

FIGURE 5.4
PROJECT DEVELOPMENT STEPS: NEW CIES NETWORKS



Project Development Steps	Issues for Promotion
Idea	• Are all the currently available CIES technology options being considered? • Is credibility for the CIES project being established among key groups?
Preliminary Investigation	• Are the key target groups aware, interested and willing to consider CIES? • Is one or more of these groups willing to provide financing for the preliminary feasibility study?
Detailed Feasibility Study	• Has a project "champion" with influence and credibility taken charge? • Has moral support from the proposed project participants been confirmed? • Are sponsors of the detailed study convinced of CIES benefits?
Project Implementation	• Are prospective customers making commitments to connect? • Is an active public relations campaign conducted for the community during construction?
System Operation	• Is ongoing support being generated from customers, regulators, suppliers and CIES company staff?

SOURCE: International Energy Agency, *Promotional Manual for System Developers and Operators, Draft* (1991).

- environmental conditions (especially outdoor air quality) can be expected to improve with the introduction of a CIES; however, siting problems may be encountered for central plants;
- incineration of municipal waste may provide a low-cost energy source and reduce landfill requirements, but public opposition to waste-to-energy plants is common; and,
- the presence of a CIES can contribute to an image of a "clean, vibrant and modern" city that will increase tourism into the downtown core and also increase demand for downtown office space.[38]

5.11.2 Translating Political Will Into Action

Extensive municipal CIES networks are common in Scandinavia and other European countries. However, few cities in North America have moved beyond older, downtown steam-based systems to establish comprehensive municipal systems. Particularly in Canada, many municipal leaders remain unaware of the environmental and economic benefits of district energy for their community. As important, translating CIES social benefits into a municipal commitment to use tax dollars and to change regulatory planning direction to enhance the economic attractiveness of CIES is somewhat rare, though it is growing. Several U.S. examples of downtown revitalization are available where the perceived community benefits of greater employment and an improved urban environment were major reasons for interest in and political support of CIES projects.

District energy systems offer many prospective benefits to a municipality. However, the process of determining the magnitude of these benefits, having them understood and appreciated by the political decision-makers, and translating political will into action is not easy. At a minimum, a "champion" of district energy systems must be found among influential municipal politicians such as the mayor.[39]

5.11.3 Promotion Activities

Consideration of a CIES may be triggered in several ways. For example, a major urban re-development project may be proposed or an available energy resource (such as available waste energy or excess boiler capacity) may be identified. Prefeasibility studies may be required to review the alternative technical concepts. For each of these, the costs and benefits to the municipality can be determined and an appropriate way to implement the CIES project can be identified.

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[38] Ibid., p. 30.
[39] Ibid., p. 32.

Visits to other systems may contribute to the credibility of the "new" district concept as well as provide a learning experience for engineers and contractors.

5.11.4 Making Informed Decisions

Municipal decision-makers should become aware and knowledgeable about the major technical options available for establishing an extensive municipal CIES.[40]

These options include:

- connecting an existing core system to nearby buildings to increase the load on an underused boiler plant;
- using cogeneration equipment to increase overall plant efficiency, reduce peak electrical demand and/or generate supplemental revenues from the sale of power;
- retrofitting existing steam lines with a lower-cost, higher-efficiency hot water distribution network;
- as building cooling requirements increase, installing central chilling equipment with a chilled water distribution system (or high efficiency steam absorption chillers that can use available steam distribution lines); and/or,
- incorporating a locally available energy source, such as heat recovery from a municipal waste incineration plant or a nearby industrial plant or use of wood waste or wood chip fuel.[41]

The experience of most Canadian consulting engineers with these technology options is limited. CIES proponents will find that engineers, planners and economists who specialize in these areas are the most appropriate sources to contact for an appraisal of the costs, benefits and risks of technical alternatives. The P.E.I. Energy

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[40] Ibid., p. 34.
[41] See Charlottetown, P.E.I in Volume II.

Corporation, Edmonton Power and CANMET can help district energy proponents find suitable Canadian expertise (see Appendix E).

5.11.5 Financial Institutions

The source of capital funds for district energy systems can vary depending on the type of system ownership.[42]

For group systems, funds are provided through the organization's capital budgeting and funding processes.

In some cases, multi-subscriber CIES raise capital through financial instruments that are obligations of (or are guaranteed by) a municipal or provincial/federal government entity. Access to funding and the cost of funding is typically related to the government entity's credit rating and is only secondarily a function of the financial attractiveness of the CIES project itself. Thus, the CIES system proponent will usually seek to gain support from government rather than deal directly with financial institutions.

For other multi-subscriber CIES, the ability to raise capital is a function of the proponent or developer being able to convince financial institutions of the long-term soundness of the CIES business plan. In these cases, the relationships that must be established are similar to those required between any business and its sources of financing.[43]

Most major CIES projects have enjoyed some form of government backing. Where governments have not been directly involved, no difficulties have been encountered in securing funding on reasonable terms where a system has a sound history of operating and financial performance. However, when a proposed system is new, the financial community may react with skepticism if they have not become familiar with the financial viability of CIES on a world-wide basis.[44]

Since the main capital requirement of a CIES is for long-term capital related to investment in central plant and the distribution network, the appropriate sources for this "type of funding" should first be identified.

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[42] International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *District Energy Systems, Promotion Manual for System Developers and Operators*, Second Draft, November 1991, p. 42.

[43] Ibid., p. 43.

[44] See Volume II for a description of government support for CIES and the use of European Integrated Resource Planning.

The financial institution will base its lending decision on the reasonableness of the cash flow projections in the business plan. The business plan must therefore provide clear evidence that:

- the technology is sound and well-proven;
- the subscribers will agree to connect and the heat/cooling load projections are reasonable;
- the gross profit cannot be jeopardized by:
    - future shifts in prices and availability of alternative fuels; and/or,
    - constraints in adjusting tariffs to levels required to ensure financial solvency;
- the management plan is sound;
- the financial plan identifies a reasonable balance between debt and equity; and,
- technical, operating, marketing and political risks are identified, assessed and managed.

A reluctance to support a CIES project sponsored by private parties may be expressed by financial institutions. In these cases, it may be possible to secure a loan guarantee from the government body whose jurisdiction will enjoy the economic and environmental benefits from the CIES project.[45]

5.11.6 Mass Media

The mass media provide the vehicle for public relations activities initiated on behalf of the district energy company. These activities build awareness and goodwill for CIES within the community. Local media are receptive to newsworthy information and appreciate receiving such information in a professional news release format. Representatives of the media should be invited to all events, such as plant openings.[46]

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[45] International Energy Agency, *District Energy Systems, Promotion Manual for System Developers and Operators*, p. 44.

[46] Ibid., p. 54.

5.11.7 Interest Groups

Certain interest groups within the community have objectives that are compatible with those of CIES development. A relationship with such groups should be established that can result in the support for CIES being leveraged by their efforts.[47]

5.11.8 National and Provincial Governments

Governments at the national and provincial level relate to district energy systems in two areas:

- at the operational level, as owners, managers, operators and/or regulators of buildings, district energy systems and electric and natural gas utilities; and,
- at the policy and program level, as agents for the public interest, both nationally and internationally.[48]

5.11.9 Owners/Managers/Operators/ Regulators[49]

Governments at the provincial and national levels own and operate thousands of district energy systems throughout the world. These are found at office building complexes, military bases, correctional facilities, airports and other locations. Governments also provide funding, either directly or indirectly, for thousands of health care and educational institutions that run on-site, central heating plants and district energy networks.

In many jurisdictions, governments at the provincial and national level are heavily involved with the generation and distribution of electricity, activities that are closely associated with district energy systems. For example, electric utilities are frequently publicly owned. Rate structures and capital expenditures are subject to the regulatory control procedures of public utilities boards, such as the Alberta Public Utility Board and the Ontario Energy Board.

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[47] Ibid., p. 54.

[48] Ibid., p. 55.

[49] Much of the following discussion is also relevant to municipal government departments and elected officials.

5.11.10 Policy and Program Agents

Regulatory agencies (i.e., Environmental Assessment Board) give approvals to a district energy system project during the design and construction phases. Drawings must be approved to indicate conformance to the governing pressure vessel code. Permits for construction of distribution networks are necessary due to the lengthy periods of road disruption. Environmental siting permits may also be required, especially when new energy sources, combustion equipment and/or stacks are part of the project. In addition, multi-subscriber systems may find that their tariff structure is regulated by the local public utilities board (i.e., Ontario Energy Board).

Project delays can be encountered, especially at the planning stages, when regulatory officials are not familiar with district energy systems. In most countries, few difficulties have been encountered in obtaining construction permits for CIES. District energy technologies are well proven. On the other hand, hot-water distribution technology has not been well established in North America. Such systems may be designed to use components equivalent to those well established in European practice. In such cases, inspectors may have difficulty in relating local code requirements with what are essentially European specifications and, in some cases, European component sourcing.[50]

Environmental siting permits may be difficult to secure, especially if there is no formal municipal, provincial or federal government policy regarding district energy and the acceptability of specific technologies, such as municipal waste-to-energy plants. Also, local citizens groups can polarize public opinion against any new project due to their uncertainties regarding the effectiveness and reliability of pollution control equipment.

Several approaches can be taken to familiarize **municipal officials** with the environmental and other benefits of district energy systems. Factual information from the experience of other district energy systems can be shared with municipal staff and influential elected figures. Visits to successful systems, including meetings with local environment officials, can be arranged to provide credibility for claims of technical performance and political acceptability. Meetings with non-government groups and the media can be organized to provide education and reduce the risk of confrontation.

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[50] International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *District Energy Systems, Promotion Manual for System Developers and Operators*, Second Draft, November 1991, p. 41.

Environmental benefits that can be emphasized include:

- Greater efficiency in fuel use which reduces the amount of CO_2 emitted, thereby reducing the community's impact on global warming. The efficiency of central boilers is in the 80-85 percent range, compared to 50-60 percent for decentralized boilers.
- The single tall stack of a central plant disperses emissions away from the municipal area, reducing local pollution levels.
- Single point emissions are much easier to control and monitor with state-of-the-art pollution control equipment.
- Where municipal solid waste can be incinerated, the use of available waste streams as an energy source (rather than landfill) provides for the displacement of conventional fuels, thereby reducing CO_2 and CH_4 emissions. It can also reduce landfill requirements by up to 90 percent (see Part II).

Among **International Energy Agency** member countries, major differences are found in the extent to that governments understand the role of and provide support for district energy systems. In some European countries, as shown in Table 5.1, CIES are supported by clear policy positions and various forms of legislation and public subsidies. Many European countries translate policy support into commitments for district energy systems by connecting their government-owned buildings and utilities to CIES.[51]

In North America, the situation is quite the opposite--there is remarkably lower level of government policy and program support. Governments in North America have been reluctant to provide more than **token** recognition of the social, environmental and economic benefits of district energy systems.

5.12 Research and Development

If the environmental challenges of global warming, atmospheric ozone depletion, acid rain and local air pollution are to be cost-effectively addressed, those technologies that offer real potential for problem resolution in the near future, at costs and with methods that are acceptable, need to be developed. There are few if any energy supply or demand reduction strategies that can be readied in the short term to meet Canada's environment challenges more effectively than advanced CHP and CIES technologies.

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[51] Ibid., p. 56.

Development and demonstration of advanced CIES technologies should be accelerated in order for district energy to achieve its potential for increasing energy efficiency, reducing CFC and greenhouse gas emissions, lowering electric peak loads, and providing opportunities for the export of Canadian technologies and processes.

5.12.1 Distribution System

The distribution system is a major cost of a CIES system, so reducing distribution costs is a key research and development (R&D) objective. Costs could be reduced through a number of means, including friction reduction additives, phase change materials, non-metallic pipe, lighter metallic pipe and improved construction methods. For district energy, friction reduction additives are expected to provide benefits before phase change material technology is well developed. Surfactants appear to be the most promising friction reduction additive, although polymers and polyester filaments have also been studied. Phase change research could have a tremendous impact if successful, although it is a higher risk, longer-term effort. For district cooling, ice slurries offer a means for distributing chill energy in much smaller pipes as well as making storage more cost effective.

5.12.2 Heat Based Chilling

The development of high-efficiency, low-cost, heat-based chilling is a research focus that could markedly benefit existing and prospective district energy systems. Filling in low summer loads with cooling customers could result in additional revenues, increased boiler efficiency, lower costs per unit output due to better equipment use, and reduced distribution losses per unit of output. An additional argument for the development of heat-activated chilling technology is that these systems will accelerate the replacement of CFC-based chillers.

A high priority in absorption refrigeration technology R&D is the development of an advanced, high-efficiency, low-cost, double-effect absorption chiller integrated with state-of-the-art small scale (100 kW-1MW) natural gas-fired diesel engine CHP systems. Such a system could be developed within a few years with adequate funding. A second priority is the development of a triple-effect absorption chiller for integration into a similar cogeneration system. Oak Ridge National Laboratory has developed a theoretical design that may be capable of attaining very high efficiencies coefficient of performance (COP of 2.0) in CHP applications. The successful commercial development of such a system is four or five years away, given adequate levels of funding.

One of the highest priorities in Canada is to couple single effect chillers, that operate with low steam pressure, to cogeneration devices. Of particular interest is the development of an absorption ice slurry generator; Canada already has an international lead in ice slurry technology.

Neither absorption chiller system would employ CFCs and both could run off the exhaust heat from a cogeneration system rather than natural gas or oil burned in a boiler or electricity. If R&D developments prove out, CIES technology could facilitate the elimination of CFCs in building air conditioning systems.

While several universities have chilled water systems or steam driven chillers in buildings, many potential projects are not proceeding because of the high cost estimates for chilled water distribution systems. If these costs can be reduced, perhaps through innovative technology, the cooling market would expand.[52]

5.12.3 Heat Meters

Technological factors such as efficiency, reliability and flexibility of fuel types favors centralized heat generation for community use rather than dispersed individual home and building systems. The only major technical problem associated with district energy to be overcome is the development of a small, inexpensive heat meter. To date, such heat meters have been expensive. As a result, billings to district energy consumers have been computed not by individual consumption, but by a proportional share of group consumption. Such billing methods have not created any real problems in Europe as long as district energy has been more economical than individual home heating.[53]

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[52] Michael J. Wiggin, Energy, Mines and Resources Canada, "District Heating In Canada: Where We Are and Where We Are Going," *District Heating & Cooling*, Vol. 75, No. 3, First Quarter 1990.

5.12.4 Low Cost Thermal Resources

Many low cost heating and cooling resources, such as ground water aquifers and waste heat from sewage treatment plants, industrial plants and electric utilities, are not currently used. The ability to cost effectively use these resources may make district energy economically attractive in many communities. District energy's inherent economies of scale puts it in a good position to take advantage of such sources. The use of industrial waste heat, for example, from a steel industry, could have a major impact on cost-effective district heating. There are a variety of technological and institutional reasons why these resources aren't used more. One important barrier to the use of low grade heat sources is that their temperatures are often too low to be effectively used in district energy systems. However, the trend in European systems is toward lower district heating temperatures, which opens up new possibilities for heat sources.[54]

5.12.5 Fuel Cells

Combined cycle coal gasification is the coal technology of the future and its emission characteristics are such that it can be located fairly close to urban centers. Alternatively, coal gasification/fuel cell plants could be located in downtown core district energy plants (see Figure 5.5).

"We believe that gasification-based coal technologies will become increasingly important, first for environmental reasons and then for economic ones," says Ron Wolk, director of the Electric Power Research Institute's (EPRI) Advanced Fossil Power Systems Department.[55]

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[53] Monenco Consultants limited, DHM Energy Consults Ltd., K-Konsult, and Cogeneration Associates Limited, *The Realistic Potential for District Heating in Canada, Volume I*, April 1985, p. 46.

[54] Mark Spurr, "Research and Development: The Future of DHC," *District Heating and Cooling*, Vol. 73, No. 4, 1988, pp. 17-18.

[55] John Douglas, "Fuel Cells for Urban Power," *EPRI Journal* (Palo Alto, California: Electric Power Research Institute, September 1991), p. 5-11; and K. Morgan MacRae, *New Coal Technology and Electric Power Development*, CERI Study No. 38 (Calgary, Alberta: Canadian Energy Research Institute, April 1991).

FIGURE 5.5

FUEL CELLS--THE SUPERFLEXIBLE POWER TECHNOLOGY

Ideal for dispersed generation, fuel cells offer attractive technical and operating advantages, including a variety of avoided costs and environmental benefits

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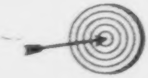
Siting. Because fuel cell power plants cover only a small area and produce very low emissions, they can be sited near centres of load growth, including congested urban areas.

Fuel flexibility. Although early commercial units will be fueled with natural gas, it is expected that molten carbonate fuel cells (MCFC) will eventually use gas produced by the gasification of coal--by far the cleanest way of using this fossil fuel.



Efficiency. Fuel cells are the most efficienct means of generating electric power from fossil fuels, with the conversion efficiency for MCFC approaching 60 percent.

Dispatch. Fuel cells can respond to load changes in seconds--which makes them perfect for serving peak loads--and function efficiently at either full or partial power.

Modularity. The first commercial MCFC plants will be available in 2-MW modules, so utilities can add single units quickly as demand growth warrants.

T&D deferral. Adding or upgrading transmission and distribution facilities in urban areas is becoming more difficult; installation of a small fuel cell power plant offers an attractive alternative.

SOURCES: Canadian Energy Research Institute and *EPRI Journal* (September 1991).

Compact, quiet, highly efficient, and exceptionally clean, fuel cell modules can be installed as needed on available urban sites, without the need to invest in large remote power plants and upgraded transmission lines. In addition, they respond well to load changes, can be used to correct power factor degradation in the urban grid, and offer considerable flexibility in the choice of fuel. Early applications will probably include dense urban areas facing severe environmental constraints, substation upgrades, and cogeneration opportunities in industrial parks and new urban communities.

In a fuel cell, gaseous fuel (such as hydrogen, natural gas, coal gas, methanol, or naphtha) and oxygen (either from the air or purified) flow through porous electrodes, which are only slightly affected by the reactions. Unlike conventional generation systems, fuel cells employ an electrochemical process where fuel is converted into electricity through flameless oxidation. Skipping the combustion step makes the energy conversion process much more efficient than using a boiler to raise steam. It is also much cleaner.

Under a commercialization plan cofunded by EPRI, construction of demonstration units is expected to begin by mid-1993. If demonstrations are successful and if utility commitments have been received within a three-year solicitation period for 100 MW or more of early production units, a commercial-scale manufacturing plant will be built.

As a long-term strategy, coal gasification is expected to replace natural gas as the primary source of energy for fuel cells. Although the electricity generation demand for natural gas--now used mostly in combustion turbines--is expected to double by the year 2000, only a fraction of this gas is being supplied on a firm, noninterruptible basis. There is a reasonable probability that within a decade gas prices will rise substantially, promoting the use of coal-derived synthetic gas. Fuel cells are much more efficient than turbines in using either natural or coal-derived synthetic gas.

The 1990 amendments to the U.S. Clean Air Act will also make the combination of coal gasification and fuel cell heat and electricity generation more attractive. Over the next few years, many U.S. utilities will be required to halve their sulphur oxide emissions and to reduce nitrogen oxide emissions by 30 percent. After 2000, total emissions will be capped, and utilities will be issued emissions allowances that can be traded among "clean" and "dirty" plants. Since gasification is by far the cleanest way to use coal, and fuel cells are by far the most efficient way to generate power from the synthetic gas, the combination of these two advanced technologies will offer an especially attractive way for utilities to stay below the new emissions cap.

Over the next five years, natural gas-powered fuel cells, that have just become commercially available, should become an economic means of cogenerating heat and electricity. Fuel cells promise essentially zero pollutant emissions and offer quieter operation than existing natural gas-turbine CHP systems. Recognizing this, Toronto's Special Advisory Committee on the Environment recommended that Toronto City Council solicit support from Ontario Hydro and Consumer's Gas in setting up a fuel cell demonstration for the combined generation of electricity and heat. It should be remembered that a fuel cell is a combined heat and power technology that can benefit greatly if the reject heat is used, thereby increasing efficiencies to over 90 percent.

We conclude by reiterating as recommended in previous CERI presentations and studies, that considerably more Canadian research should be directed to fuel cell commercialization and applications demonstration in Canada.

5.12.6 CIES Researchers

On the technology side, there is a small but active nucleus of CIES researchers who are working closely with industry and system operators. One group is working on advanced fluids including friction-reducing additives for hot and chilled water systems, low temperature cooling water supply impact on systems, and ice slurry generation and transport. Other projects include manuals on cost-effective building connections, comparative evaluations of steam and hot water technology, and the development of design manuals to assist in more cost-effective system design. Much of this work includes a high level of cooperation with researchers in both Canada and the United States as well as many other international groups through the International Energy Agency.[56]

CANMET in cooperation with research organizations, industrial and government partners and the International Energy Agency, manages the following initiatives to foster the implementation of community integrated energy systems in Canada:

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[56] Michael J. Wiggin, Energy, Mines and Resources Canada, "District Heating In Canada: Where We Are and Where We Are Going," *District Heating & Cooling*, Vol. 75, No. 3, First Quarter 1990.

- A marketing and communication initiative disseminates information on the community and environmental benefits of integrated energy planning.

- Information is provided on technologies for generation of combined heat and power, district heating and cooling technologies, industrial waste heat utilization, and heat pump applications.

- Studies are made to assess system cost, financing, incentive programs and the commercial viability of integrated energy systems in Canadian communities.

- R&D focusses on improving systems and components to minimize cost and maximize energy efficiency while replacing premium fuels with low-cost, locally available energy such as power plant waste heat, industrial waste heat, and alternative energy forms.

Research in systems development includes:

- developing technologies and methods for economically retrofitting existing steam systems with more efficient hot water systems;

- optimizing the use of cogeneration technologies to better serve integrated energy systems;

- developing heat recovery cycles to improve overall energy efficiency of fossil-fuel-fired utility plants; and

- optimizing the application of community integrated energy systems.

To improve the economics and the efficiency of CIES, CANMET is performing research on new distribution piping installation techniques and equipment; piping systems for heat and cooling distribution; metering; building system controls; heat pump development; fuel flexibility; and thermal storage (Appendix C contains a detailed description of CANMET's community integrated system initiatives).

Chapter 6

RECOMMENDATIONS

6.1 Introduction

During the 1970s, rapidly rising energy prices focussed attention on the cost and availability of future Canadian energy supplies. Numerous off-oil and energy conservation programs were put in place to reduce energy price impacts on the economy and to lessen security of supply concerns. The environmental challenges of the 1990s are calling for similar broad-based strategies that will achieve greater energy efficiency and reduce environmental impacts, while and at the same time ensuring that these actions do not place Canada at a competitive disadvantage relative to its trading partners. Investigating energy-environment-economy linkages is fast becoming a national priority.

This chapter sets out various recommendations regarding actions that are needed for district energy to prosper across Canada. Reference is commonly made to the situation in Ontario. This is not to suggest that district energy's prospects in Ontario are any better than its prospects in other provinces. Rather, reference to Ontario is made so that industry and government decision-makers in other provinces can appreciate how various issues and recommendations relate to them. For example, instead of recommending in a generic vein that "regulatory boards should do this and that", specific reference is made to the Ontario Energy Board and the Environmental Assessment Review Board. Regulators in Alberta can, for all intents and purposes, read these as the Alberta Public Utilities Board and the Alberta Energy Resources Conservation Board.

A discussion of changes required to place Community Integrated Energy Systems (CIES) on a level playing field with Canada's other energy supply and demand options is presented below. As the recommendations are extensive, an introduction to the issue is given to provide some context for the recommendations that follow.

6.2 Government Support

6.2.1 Government Commitment to Energy Efficiency

Potential customers appear hesitant to commit to long-term contracts for cogenerated thermal energy without knowing details of delivered cost and operating reliability. Reluctance to invest is exacerbated as district energy requires large capital outlays and long payback periods. These barriers cannot be resolved without government policies that support the cost and efficiencies of CIES and financial incentives that resolve existing institutional and market barriers. As indirect benefits such as emissions reduction do not accrue to the CIES developer, the value of these benefits may be an appropriate benchmark for government support of CIES projects.

Environmental externalities represent an important reason for examining sharing of risks so that CIES projects might go ahead. Governments might play a catalyst role in helping to promote acceptance and construction of CHP-based district energy projects in Canada based in part upon the demonstrated improvements in environmental quality this technology offers Canadian communities.

Cogeneration of heating, power and cooling are proven technologies that have been applied in many places around the world. CHP gives a major improvement in energy efficiency. Carbon dioxide emissions from CHP plants could be 60-70 percent less than those from separate coal-fired plants. This clearly indicates that CIES using conventional technology surpasses any imminent or developing technology. District energy not only ensures fewer emissions per useful unit of energy output, but the potential to install emission control equipment is both greater and cheaper per unit of energy produced. This means that considerably less fuel is consumed, resulting in a substantial reduction in waste emissions of all forms.

In most cities in North America, natural gas and fuel oil meet the bulk of space heating and domestic hot water demand. Improving energy efficiency is of interest now and for the foreseeable future, because of public concerns with the greenhouse effect, acid rain and the destruction of the earth's ozone layer. Cogenerated district energy can supplant natural gas and oil-fired space heating in high- and medium-density commercial, institutional and industrial load areas. This can make Canada's natural gas and fuel oil supplies available for a longer period for use in lower density uses such as transportation and petrochemical production.

Government policy-makers with full support of the Canadian public must recognize the benefits provided by CIES and work through changes in policy, planning and incentive mechanisms to establish this vision. Unlike many other energy options, technology is not the main problem. CIES technology is readily available and commercially proven.

Federal, provincial and municipal governments are owners of, and tenants in, massive amounts of commercial office space in the downtown core areas of Canadian cities. For example, the federal government owns or leases 25 million square metres of office space. Canada's provincial, regional and municipal governments own or lease many more millions of square metres of office space, most of it located in Canadian city downtown cores.

Government commitment to use district energy can be viewed from two perspectives. District energy provides lower capital cost for heating and cooling when all costs, including capital, labour, maintenance, and supplies, as well as fuel, electricity and environmental impacts are accounted for. An equally important reason for government support is that government procurement of new technologies would lead to rapid advances in those technologies, resulting in accelerated market introduction and enhanced overall economic gain for Canada. Export opportunities for Canadian district energy companies and consulting engineers would also be enhanced.

Recommendations

- A policy of connecting government-owned facilities on a long-term contractual basis to a CIES network and favoring the leasing of commercial office space from buildings connected to CIES would greatly assist district energy projects with the important initial baseload necessary to make CIES economically and financially attractive across Canada.

- Federal and provincial policy should be changed to increase awareness of district energy and the role which it can play in Canadian energy development. For example, in many parts of Europe district energy and community Integrated Resource Planning are top priorities for improving efficiency and reducing environmental impacts.

- To ensure that CIES is considered as a potential solution for Canadian energy-environment-economy issues, coherent strategies must be developed to overcome institutional barriers such as existing legislation, regulations, standards, practices and attitudes. Coherent marketing programs together with financial incentives are also needed.

6.2.2 Policy Initiatives

The CIES function of distributing energy when and where it is needed must be broadly marketed to decision-makers and the general public. Common ground must be found to carry out cost-effective energy-environment-economy solutions.

Recommendations

District energy should be made part of a comprehensive strategy for boosting energy efficiency and improving Canada's energy-environment-economy linkages. Various incentives, both financial and of a non-financial nature, together with changes in Canadian energy-environmental-economy planning and broad-based marketing programs are needed. These changes are required to hasten CIES development so that Canadians can reduce their emissions of greenhouse gases and reap the many other benefits of community integrated energy networks.

Industry and government initiatives should be considered which will help all Canadians to realize that:

- cogenerated heating, power and cooling is one of the best ways to reduce pollution;

- CHP systems offer a highly economic option for improved end-use energy efficiency, especially when combined with waste heat recovery or the use of renewable or low-grade thermal energy sources;

- there is no significant technological barrier to prevent the use of CIES; and

- district heating and cooling can be a valuable addition to a community's infrastructure, by providing another service for its citizens.

Government and industry should assess:

- development of improved power siting criteria to favor locations closer to heating, cooling and process loads such as urban and industrial centers;

- improved awareness of the feasibility of transporting hot water over long distances;

- identification of existing heating and cooling loads and retrofit of power stations to CHP where feasible;

- equitable pricing systems and negotiating procedures for the purchase of electricity from cogeneration facilities;

- consideration of waste heat recovery from industry, waste incineration or other low grade fuel or heat sources; and

- a call for more efficient use of the energy available in our fuel resources through more efficient methods of converting that energy to a useable form. It is important not only to focus on energy consumption, but on the effective and efficient use of the energy present in our fuel resources from the very beginning.

Government and industry should take steps to encourage:

- comprehensive Integrated Resource Planning (IRP) in all communities;

- the incorporation of CHP systems as essential elements of energy and environmental planning;

- identification of legal and financial constraints to CIES and their resolution;

- assessments of the direct economic and environmental benefits of CHP systems with the real costs of individual energy production and required environmental controls;

- community energy education programs which elevate the awareness of district heating and cooling systems among business and government leaders, educational institutions, environmental actions groups and others; and

- responsible non-government organizations to be involved in community IRP to help overcome the NIMBY virus.

Government and industry should take steps to:

- establish awareness of and credibility for the social and economic benefits to be realized by increased acceptance of district energy systems;
- establish an understanding of how the technical, economic and environmental feasibility assessments of proposed district energy system projects should be conducted;
- identify specific district energy technology opportunities that require demonstration support;
- identify regulatory barriers that are impeding the acceptance of district energy systems;
- establish awareness of and credibility for the range of technical options that are available or are at the demonstration stage for improving operating performance, optimizing system capabilities and adapting to new factors, such as environmental concerns and utility buyback policies; and
- provide guidance as to how both preliminary and detailed feasibility assessments should be undertaken for the technical options that may be used for their systems.

Government policies should be changed so that:

- district energy is a key element in Canada's national energy strategy to increase energy efficiency through cogeneration and other means, reduce CFC use, reduce GHG emissions and reduce electrical peak loads;
- increased CHP is a major goal of Canada's national energy strategy;
- district cooling is recognized as an important strategy for controlling growth in peak electric demands;
- air quality regulations are changed so that emissions are regulated according to the useful energy provided. District energy fits well, for example, with Alberta's Clean Air Strategy view of moving from point source emission levels to regional zoning that accounts for the capability of the regional airshed and watershed to absorb emissions of a specific level--e.g., emissions from a district energy plant might increase emissions near the plant but would significantly reduce regional emission levels; and

- research, development and demonstration of advanced CIES technologies is substantially increased in order for district energy to achieve its potential.

Government should assess various programs in support of accelerated CIES development including:

- provision of loan guarantees;
- prohibition of new point source pollutants for heat or energy generation unless waste to energy systems are included;
- granting of zoning requests for downtown waste processing facilities;
- the issue of specific guidelines defining public regulatory jurisdiction over waste-to-energy district heating and cooling systems; and
- where feasible, encourage government energy/heat consumers to enter into long-term contracts with district energy systems.

6.2.3 Coherent Government Programs

To ensure the success of programs designed to promote greater awareness of district energy, it is important that information be presented in a coherent manner. Unfortunately, the various levels of government in Canada--municipal, regional, provincial and federal--make it difficult to coordinate programs for the adoption of certain energy conservation technologies.

Both private and public owner-investors must be assured of a fair economic return, in keeping with the risks involved in the development of new utilities and services. Legislative action is required to define policy and remove barriers to owner-investor assurance and confidence in the long-term economic feasibility of CIES development. Adjusting regulatory review processes (i.e., Ontario's Environmental Assessment Board and the Ontario Energy Board) to credit the reduction in emissions from district energy systems is also imperative.

Recommendations

The federal and provincial governments, in consultation with business and industry, should undertake a detailed examination of energy efficiency programs to increase program utility and accessibility. Following this appraisal, federal, provincial and municipal regulations should be changed if they present barriers to CIES project development. Adjusting regulatory review processes to provide for a one-window approach (i.e., Ontario's Environmental Assessment Board and Ontario Energy Board joint hearings) and crediting the reduction in emissions from district energy systems is also warranted.

Achieving Toronto's goal of a 20 percent reduction in greenhouse gases will be facilitated through the active assistance of Toronto Hydro and a change in Toronto Hydro's corporate mission. Toronto Hydro's new mission should be to help its customers meet their energy service needs at the lowest possible social (economic and environmental) cost.

To achieve this, Toronto Hydro should:[1]

- encourage increased efficiency in the use of electricity through rate reforms, public information programs and incentive programs;
- purchase electricity from independent power producers (such as natural gas CHP facilities) where such purchases are a cost effective means of reducing CO_2 emissions; and
- promote substitution of natural gas for electricity when this can be shown to reduce CO_2 emissions.

The transformation of Toronto Hydro into an energy service company implies a fundamental change in the relationship between Toronto Hydro and Ontario Hydro. In particular, it would be in the public interest to develop a mechanism whereby Ontario Hydro can buy conservation services from municipal utilities at an avoided cost that reflects full societal costs including environmental costs.

Rapid implementation of the following is needed:

- elimination of the decreasing block structure;
- elimination of the minimum monthly bill;
- abolition of flat rate service for water heating; and

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[1] These recommendations require appropriate amendments to Ontario's Power Corporation Act.

- development of other pricing mechanisms that will induce greater conservation of electricity.

6.2.4 Risk Sharing and Financial Incentives

District energy is a capital intensive technology that requires substantial front-end investment by the developer and, to a lesser degree, by the subscriber to replace or retrofit existing heating systems. Moreover, as district energy investment usually involves wider investment criteria than other heating systems, potential developers and the investment community often consider it to be a riskier investment than other supply options.

Recommendations[2]

- High capital costs, a need for well trained operation and maintenance personnel as well as jurisdictional issues favour joint venturing between government, industry and utilities as the ideal arrangement for promoting CIES projects and a greater appreciation of the benefits of CIES and IRP to Canadian urban communities. Environmental externalities, represent an important reason for examining sharing of risks so that district energy projects might go ahead.

- Risk aversion plays a major role in the decision not to participate in a CIES program--people fear the uncertainties involved with new technologies, particularly where capital costs are high. If utilities and/or government can reduce these fears directly or indirectly, customer behavior will be positively impacted. Since investment to increase sales is preferred, increased investment in more energy efficient technologies will only take place if it is encouraged with additional financial incentives. The infusion of government financial support could be of major assistance if it were oriented toward sharing the burden and risks taken by CIES investors.

- If CIES were financed at the low interest rates now enjoyed by Canada's regulated utilities, this could provide a strong incentive for CIES development. For example, government loan guarantees with repayment tied to revenues following project payback, are strategies worth considering by federal provincial and municipal government(s).

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[2] These recommendations require appropriate amendments to Ontario's Power Corporation Act.

- A further incentive would be for energy produced by CHP to be sold to gas and electric utilities at the utilities avoided cost of generating heat and power. Making allowance for the reduction in environmental emissions produced by CHP-based district energy systems is also imperative. Comprehensive Integrated Resource Planning for heat and electricity could bridge the knowledge gap and remedy the current situation until full cost accounting is accepted as a means of improving energy-environment-economy decision-making.
- Municipal utilities such as Toronto Hydro in coordination with Ontario Hydro should consider providing incentives to customers to help them replace inefficient equipment with state-of-the-art equipment. The incentives might require paying up to 100 percent of the cost of energy efficiency measures in order to overcome market barriers.

Toronto Hydro should be given the option of paying for efficiency investments by borrowing in order to minimize rate shock. At present, Toronto Hydro must treat energy efficiency investments as operating costs that must be recovered during the year in which they are made. The provincial Power Corporation Act should be modified to allow efficiency investments to be treated as capital investments, so that Toronto Hydro can borrow to finance these investments as assets.

Toronto Hydro should seek financing from Ontario Hydro of as many of its energy efficiency programs as possible. Ideally, Ontario Hydro should finance all of Toronto Hydro's CO_2 emission reduction policies as these will reduce the need for new generation and transmission facilities. However, Ontario Hydro's avoided cost calculations do not include externalities, except for a 10 percent credit for renewable supplies but not for conservation.[3] Until that policy changes, Toronto Hydro may have to finance some of the programs required to reach City Council's 20 percent goal.

Incentive programs could take the form of low interest financing, cash rebates, or leasing arrangements so that the customer does not have to assume the upfront costs. Toronto's Energy Efficiency Office should give serious consideration to undertaking several conversion demonstration projects for representative building types. At least one of the projects should incorporate a natural gas CHP system that uses the heat from the combustion process for space heating during the winter, and absorption cooling during the summer.

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[3] Ibid.

Substantial financial support would be available from Ontario Hydro for such an effort to help offset the high initial investment required by the City.

6.2.5 Municipal Integrated Resource Planning

To deal effectively with energy-environment-economy issues within today's urban environment, a new approach to energy planning for Canadian urban communities is needed--a planning approach that goes beyond the fractionalization that has characterized Canadian heat and electricity planning. To become more energy and environmentally efficient and to ensure minimal impact on the Canadian economy, we need to develop institutional mechanisms that look at the big picture.

The NO_x/VOC Management Plan, the Green Plan, the Canada-wide Environment and Economy Roundtables and Alberta's Clean Air Strategy are all indicative of a trend to greater breadth in decision-making participation and Integrated Resource Planning across Canada.

More efficient land use patterns that require less energy for such functions as space heating and transportation and more efficient infrastructure design facilitate the use of renewable energy, waste heat, and alternate energy technologies such as district energy. **To be successful, district energy must become an integral component in community planning, design, and development**. By expanding a community's comprehensive planning to include heat planning, a community can create a land-use framework that is more energy and environmentally efficient and more conducive to district energy. Long-range IRP with cooperation between local authorities, oil, gas and electric utilities, and the public is essential to minimize problems associated with siting power plants in urban areas.

Recommendations

- The need for a new Canadian regulatory process and planning regime is critically important--one that can account for the many tradeoffs involved in assessing energy-environment-economy impacts.

- Policies that **actively** support Integrated Resource Planning in urban areas across Canada are required if we are to fully develop the potential for community integrated energy systems. Integrated Resource Planning, where regulators responsible for space heating (e.g., gas) and electric power hold joint hearings on regional energy needs (both heat and electricity), is needed. This was the principal reason for the growth in district energy and the attendant energy-environment-economy improvements seen in many Scandinavian countries.

- Integrated Resource Planning can be best accomplished by redefining the Canadian regulatory process to focus on determining the approach that will provide the lowest cost per unit of useful energy provided, including consideration of social and environmental externalities.

- In order to best manage Canada's community energy supplies and end-use energy demands, heat plans should be formulated and implemented as an integral part of a Canada's overall planning and development strategy for a more efficient energy and environmental future.

Canadian community heat plans should be concerned with the following:

- systematic monitoring of current and forecast heat supplies and demands;

- conservation of heat through more rational and efficient land use and building standards, and end-use technologies;

- development of alternate heat resources such as biomass, geothermal, cogeneration, waste recovery, and industrial waste heat use;

- optimizing the locational matches between heat sources and end-use energy demands;

- integration of heat supply and demand planning with other traditional community planning sectors, such as housing, transportation, and employment in order to make thermal energy a key determinant in the community development process; and

- reduction of the gross fuel requirements of the community through the cumulative efforts of heat plan implementation.

Greater municipal involvement is required, aided by federal and provincial financial and analytical staff support.

- The federal government should continue to maintain its current responsibility for CIES research, development, demonstration and technology transfer.

- Monies for federally and provincially funded CIES feasibility studies should be substantially increased.

- The Canadian version of HEATMAP should be made available to all interested parties--research institutes, engineering schools and consultants, and energy departments at the provincial and municipal level. Only where many parties are in a position to evaluate the costs and benefits of CIES can costs for these systems be kept as low as possible.

Common sense and international competition dictate that Canada do away with the inefficient duplication of regulations that stand in the way of greater energy efficiency, an improved environment and greater economic prosperity for Canadians.

- Using Ontario as a case in point, joint hearings by the Ontario Energy Board and the Environmental Assessment Board would ensure the best fit of new capital and demand- and supply-side resources for the provision of both heat and electric power for urban communities. It would also reduce administrative costs--costs that are making some urban projects uneconomic.

- The Toronto Department of Public Works and the Environment should assess the feasibility of various CIES projects, together with the economic spin-offs to Toronto of these projects and how they might best be integrated with other plans for urban development--i.e., transportation arteries, waste disposal and waste heat use. Local authorities could require that district heating and cooling was considered before any major building permit was issued in CIES target areas. The Ontario Ministry of Energy could provide important input by assessing the least-cost impacts of alternative IRP strategies on the Ontario economy.

- Central government guidelines regarding community IRP are required together with some form of central government analytical assistance so that Canadian municipalities are better able to investigate the energy-environment-economy impacts of alternative community integrated resource plans. Alternatively, federal and provincial government experts could be seconded to municipal government departments charged with implementing IRP and district energy feasibility studies. This option provides a unique opportunity to put "the expertise" where the expertise is needed. These civil servants would also know where to go to obtain the best input of other federal and provincial government departments instrumental to fully develop IRP and CIES.

- Finally, as most present day Canadian issues are really urban issues--i.e., transportation, urban crime, illiteracy, the urban poor, housing--this move would be an advanced vanguard of what will ultimately be needed to solve many issues of concern to Canadians.

As indicative of those actions municipalities across Canada might take, the City of Toronto should pursue:

- a ruling by the Ontario Energy Board that the mandate of Consumer's gas should include the aggressive promotion of energy efficiency and conservation in addition to its service role as a natural gas distributor; and
- the establishment by the Ontario Energy Board of rate making mechanisms that will ensure that the aggressive promotion of energy efficiency and conservation by Consumer's Gas is in the interest of Consumers' shareholders.

6.2.6 Feasibility Studies

Feasibility studies are expensive and time consuming. Lack of clear government support and direction adds to delays and increases costs.

Recommendations

Federal and provincial government financial and staff analytical support to municipalities, and to gas and electric utilities, for district energy feasibility studies would help overcome this barrier. For this to happen, government must earmark greater funds for feasibility studies and the use of programs such as HEATMAP. As district energy fits well with federal government Green Plan objectives, it is appropriate that some of these funds be diverted to CIES development, particularly if Canada hopes to stabilize GHG emissions in the next eight years.

6.2.7 Promoting New Technologies

Due to economies of scale, CIES can cost-effectively implement sophisticated pollution-control systems and advanced combustion technologies. District energy technology could be instrumental in realizing the use of indigenous resources and furthering the commercial development of technologies such as Integrated Gasification Combined Cycle and Pressurized Fluidized Bed Combustion. The application of these technologies could be of considerable assistance in furthering Canadian demonstration. In addition, this would assist the sale and export of Canadian technology to countries that are in need of cost-effective solutions to mounting environmental problems.

Over the next five years, natural gas-powered fuel cells, that have just become commercially available, should become an economic means of cogenerating heat and electricity. Fuel cells promise essentially zero pollutant emissions and offer quieter operation than existing natural gas-turbine CHP systems.

Recommendations

Toronto City Council, through its Department of Public Works and the Environment should solicit support from Ontario Hydro and Consumer's Gas in setting up a fuel cell demonstration for the combined generation of electricity and heat.

Canadian research institutes should evaluate the community wide implications on heat and electric power of fuel cell implementation across Canada.

6.2.8 Marketing and Training

6.2.8.1 General

Given its rudimentary position in Canada's current energy mix, it is not surprising that an important obstacle is a shortage of skilled Canadian personnel. Most builders and their tradespeople have little understanding of CIES and Canadian engineering firms and consultants are unfamiliar with European state-of-the-art hot water systems, and advanced chilled water or ice slurry systems.

The challenge facing district energy system proponents is to gain the maximum possible level of support from the many organizations and individuals that can influence CIES projects. For district energy to gain acceptance in Canada's competitive space heating market, potential subscribers (i.e., tenants and building owners) must be confident in this technology. The fact that CHP-based CIES are technologically proven must be firmly established with investors, gas and electric utilities, engineering and architectural consulting firms and municipal decision-makers. To gain acceptance of building owners, CIES developers must show them system advantages, including reliability, long-term availability, reduced maintenance and operating cost and lower on-site capital costs.

Municipal officials need to be made aware of the major technical options available for establishing an extensive municipal CIES.

These options may include:

- connecting an existing core system to nearby buildings to increase the load on an underused boiler plant;
- using cogeneration equipment to increase overall plant efficiency, reduce peak electrical demand and/or generate supplemental revenues from the sale of power;
- retrofitting existing steam lines with a lower-cost, higher-efficiency hot water distribution network;
- as building cooling requirements increase, installing central chilling equipment with a chilled water distribution system (or high efficiency steam absorption chillers that can use available steam distribution lines); and/or,
- incorporating a locally available energy source, such as heat recovery from a municipal waste incineration plant or a nearby industrial plant or use of wood waste or wood chip fuel.

Despite the fact that CIES technology would accomplish greater DSM, few Canadian utilities have acknowledged DSM benefits because most do not fully appreciate district energy's potential to more effectively use energy and to improve the environment. This is equally true of regulatory organizations charged with evaluating gas and electric policy, and economic and environmental planning at the provincial, municipal and federal government(s) level.

While financial attractiveness tends to be the most important consideration, potential subscribers may be swayed in their evaluation by other tangible CIES benefits. These benefits should be clearly presented to prospective customers and the public alike as it will be easier to "sell" the CIES concept to building owners if the public recognizes that CIES technology can be a cost-effective solution to the environmental problems faced by Canadian urban communities.

Benefits include:

- convenience to property managers through reduced maintenance requirements for energy systems;
- long-term security of an economical energy supply through flexibility of the central heating plant in using alternative fuels and energy sources;
- the removal of concerns regarding future regulations of emissions, stacks and other environmentally sensitive factors as these responsibilities are taken over by the CIES;
- potential for the long-term, least-cost energy supply since district energy is able to switch to the lowest-cost energy source (e.g., heavy fuel oil vs. natural gas at interruptible rates) and waste energy supply (e.g., industrial waste heat, cogenerated heat or incineration of municipal wastes);
- greater cost effectiveness in meeting emissions and other environmental regulations;
- greater reliability of supply of thermal energy with district energy through greater redundancy of capacity, flexibility of fuels used and rigorous maintenance procedures;
- greater comfort of building occupants; and
- technology development to improve the cost effectiveness of systems based on (1) absorption cooling that can use district energy; (2) central chillers using ammonia or other refrigerants; and, (3) lake water or other low cost sources of chilled water.

Recommendations

- Engineers, designers, system operators, maintenance personnel and other professionals who can design, construct and operate district energy technologies and processes are required.
- Federal, provincial and municipal governments should encourage and support the training of the full range of specialists needed and the promotion of

information supporting a broad cross-sectional understanding of CIES costs and benefits to Canadian urban communities. Review of Scandinavian CIES training and marketing programs would be a useful starting point.

- There is a great need to improve awareness of district energy technology and its benefits across a broad cross-section of the Canadian public--i.e., government officials, universities and community colleges, engineering consultants, environmental organizations, municipal politicians.
- Getting the general Canadian public and non-government organizations (NGOs) to fully appreciate the community benefits of community integrated energy is essential if the Not In My Back Yard (NIMBY) virus is to be neutralized.
- The experience of many consulting engineers with these technology options may be limited. CIES proponents will find that engineers who specialize in these areas are the most appropriate sources to contact for an appraisals of the costs, benefits and risks of technical alternatives.
- Representative costs for district heating and cooling systems and the application of **HEATMAP** for various test cases might also be provided to consulting engineers, provincial and municipal energy planning departments and energy research institutes.

6.2.8.2 Demonstrated CIES Benefits

To date, insufficient effort has been directed to developing projects that would demonstrate the present day costs and benefits of CHP-based district energy networks. Lacking this information, individuals, municipalities and companies will defer investment, if they believe they may be premature, ineffective, unsafe, or too costly for the potential savings they yield.

Recommendations

- Broad-based marketing directed to all potential CIES stakeholders is required on the outcome of these demonstration projects. The forthcoming IEA District Energy Promotional Manual offers a number of interesting marketing strategies.
- Central governments could help by financially supporting CIES feasibility studies that assess the

benefits to urban communities of district heating and cooling systems. In this regard, HEATMAP, should be made available to all interested parties--energy research institutes, university and community college engineering schools and municipal planning departments.

- To overcome this important barrier, the federal government in consultation with provincial and municipal government, and gas and electric utilities should pursue several projects to demonstrate the many benefits of district energy technology.
- Descriptions of successful systems, such as those in Charlottetown, Prince Edward Island, Malmo, Sweden, Copenhagen, Denmark, and St. Paul, Minnesota can increase the level of confidence that CIES is a proven, low-risk approach to community energy needs (see Part II).

6.2.9 Siting Power Plants

Cogenerated district energy requires plant siting close to heat load, commonly the downtown core of the city. While the Canadian public seems supportive of actions to minimize environmental impacts, the "Not In My Back Yard" sentiment often limits the resolve of municipal politicians to support actions, such as CIES, that would effectively result in an improved local environment and contribute to Canada's commitment to stabilizing greenhouse gas emissions.

The mass media provide the vehicle for public relations activities explaining community benefits of community integrated energy networks. Certain interest groups within the community have objectives that are compatible with those of CIES development.

Recommendations

- Representatives of the media should be invited to all events, such as CIES plant openings and should be made aware of the broad-based benefits of CIES.
- A relationship with community interest groups should be established in support of CIES and to overcome NIMBY.

6.2.10 Electric and Gas Utility Policies

The large capital requirements associated with CIES may constitute a major barrier to proposed project financing. The perceived newness of the technology, its capital intensive nature, long payback period and the substantial competitive pressures to which the project would be exposed, all serve to increase the perceived riskiness of privately-sponsored CIES in the minds of potential investors. The difficulty in gaining access to the equity capital required to finance the capital-intensive infrastructure for CIES is compounded by current utility mandates, the fractionalization of energy supply and existing competitiveness among different fuel types.

Canada's existing energy utilities are probably the best equipped organizations to deal with the barriers impeding Canadian district energy development. These utilities typically operate capital-intensive systems with long-life assets and extended payback periods. Due to their continuing need for capital, they have established their credit-worthiness in financial markets and thus have reasonable access to long-term financing required to produce a reasonable return on capital-intensive projects. Utilities also work with the longer planning horizons that are required in the development of CIES and have developed, in operating their current line of business, many of the administrative, organizational and technical capabilities required to cope with the regulatory and operating requirements of district energy systems.

Electric and gas utilities, both at the provincial and municipal level, have not generally been active in promoting CHP and district energy. Yet these utilities ought to be very interested in the greenhouse gas reduction potential of district energy. In addition, they have all the skills and knowledge that are necessary to develop and operate CHP and CIES projects. Their main concern is that they do not see their role as one that includes the distribution of heat. In many instances they view CIES as a competitive threat, rather than an opportunity to increase profits in another, but ancillary line of business.

Existing utilities exhibit notable disinterest in diversification into district energy. Until comprehensive Integrated Resource Planning or environmental cost accounting become components of the Canadian regulatory process, this situation is not expected to change.

Recommendations

Ownership of a CIES project by gas and/or electric utilities and/or municipalities having relevant related experience, established credit worthiness, reasonable access to capital and possibly government guarantees would serve as a major reduction in the perceived risk of district energy projects to customer and investors, alike.

6.2.11 Tax Credits and Incentive Programs

As industries tend to invest to increase production in preference to projects aimed at conserving energy, the government should subsidize CIES project interest rates and offer tax incentives that accelerate the adoption of technologies and processes that are in the national interest. These would result in greater investment in energy efficiency than is presently the case based upon grants and accelerated capital cost allowances that characterize existing federal incentive programs.

One device would be to provide a tax credit for any expenditures directed to greater energy efficiency, subject to previously established program criteria. Another incentive would be to subsidize low interest loans for energy efficiency projects meeting specified criteria. Federal and provincial government(s) could accelerate CIES by subsidizing project financing such that CIES projects enjoyed the lower interest rates now had by regulated Canadian electric and gas utilities.

Canadian banks, trust companies and pension funds would extend such loans, providing the difference between the rates they offer for CIES projects and going rates for other loans is financed by government subsidy. These investments would be a better risk than many bank loans to developing countries and would support moreover the Green Theme--"Lets All Work Together To Clean Up The Canadian Environment"--literature prominently displayed in many Canadian banks and trust companies.

A tax credit or subsidized interest rates would be an appropriate near-term mechanism for encouraging CIES until energy-environment-economy planning and regulations are revised to better account for our evolving understanding of the environmental externalities associated with Canadians' energy use.

Owing to the significant capital cost of the distribution piping associated with district energy heating and cooling systems, taxation can be a major factor affecting the growth of privately-sponsored district energy systems. While Class 34 appears to cover all costs associated with the development of a district energy project, there is some confusion regarding its application to CIES projects.

Recommendations

- The application of tax credits such as Class 34 Capital Cost Allowance should be clearly identified. A marketing program is then required so that all stakeholders are aware of what Class 34 does and does not apply to. Class 34 should be available to the customers of district energy systems for their substations and related piping thus diminishing barriers to connection. European CIES experience offers many appropriate roles for government support of CIES (see Part II).

- The burden of retrofitting existing buildings must be minimized for potential subscribers who generally have limited access to capital. Tax incentives, grants, provision of favorable financing, or the creation of a pricing formula for district energy that offsets retrofit costs compared to alternative heating costs are strategies that can be used to accelerate district energy development.

- Other measures facilitating the financing of district energy systems include establishment of a revolving fund for financing new or expanded CHP systems, that would generate additional funds as development takes place and the borrowers repay the fund.

- To accelerate the adoption of energy efficient measures in the residential and commercial sectors, interim financial incentives may be required. These should be in the form of interest free loans, or low interest loans, to assist builders and developers (in the case of new buildings) and owners (for existing buildings) to offset capital costs. These incentives should be offered for a period sufficient to demonstrate the advantages of adopting district energy and to train designers, tradespeople, inspectors and construction personnel.

- Adopting and recording the performance of district energy demonstrations would with time, make it possible to effectively predict the financial return to the investor. Where CIES projects lead to major savings, programs financially assisting the demonstration of their benefits would encourage their widespread adoption.

Some of the following programs should be made available so that companies can select the one that best suits their needs:

- retain the present accelerated write-off for capital expenditures on specified energy efficiency technologies listed in of the Income Tax Regulations;
- provide the option of a one-time refundable tax credit, administered through the income tax system, for capital expenditures on approved energy efficiency technologies;
- provide the option of subsidized loans at preferential interest rates, to be offered through Canadian lending institutions, for investment in approved energy efficiency technologies; and
- allow individual building owners to apply for Class 34 benefits on the costs of the energy transfer station and interconnecting piping to the existing building heating system.

Financial assistance is also required to help the subscriber in dealing with the cost of retrofitting existing building stock to district energy to ensure maximum market penetration. This assistance, provided either directly by government and/or indirectly through the district energy developer, could take the form of:

- favorable tax treatment of investment in subscriber systems;
- grants to offset the cost of retrofit;
- low interest loans, with repayment schedules related to the savings in energy costs. The objective of such loans could be that the total cost of district energy to the subscriber, including loan amortization, would not exceed his cost of heating with his existing system;
- tax incentives (investment tax audits, depreciation, etc.) to encourage inclusion of central heating/cooling systems in new development; and
- inclusion of resource recovery capital costs and construction work in progress for CIES projects in the rate base.

6.2.12 Putting CIES on a Level Playing Field

While more and more of Canada's large, provincially-owned electric utilities increasingly favour cogeneration, most of Canada's municipal utilities and municipal planners do not appreciate the potential community benefits of regionally-dispersed, CIES networks. This is another area that requires co-ordinated, proactive policy, marketing and economic analyses and initiatives by groups such as the:

- Ontario Ministries of Energy, Transportation and Communications, Treasury and Economics;
- Toronto Department of Public Works and Environment;
- Energy, Mines and Resources Canada, Environment Canada, Industry, Science and Technology Canada; and the
- Canadian Energy Research Institute (CERI), Canadian Urban Institute, and Federation of Canadian Municipalities.

Beyond financial perspectives, CIES advocates assert that the following are required to put district energy on a level playing field:

Recommendations

- ensure that full consideration is given to connecting federal, provincial, territorial, regional and municipal government buildings to community integrated energy systems;
- conduct a comprehensive assessment of the potential contribution of district energy to energy efficiency, energy-environment-economy improvements and controlling increases in demand for electricity;
- evaluate a variety of policy options, including mechanisms for recognizing the environmental benefits of district energy, encouraging CIES through tax policy, regulation and other measures; and
- increase federal government development of advanced district heating and cooling technologies and demonstrate these technologies in Canadian urban communities.

6.2.13 Research and Development

6.2.13.1 General

There are few, if any, energy supply or demand reduction strategies that can be readied in the short term to meet Canada's environment challenges more effectively than advanced CIES technologies.

Recommendations

Development and demonstration funding for advanced CIES technologies should be substantially increased so that district energy can achieve its potential for increasing energy efficiency, reducing CFCs and other greenhouse gas emissions, lowering electric peak loads and providing opportunities for the export of Canadian technologies and expertise. A collaborative relationship between the federal and provincial government(s), equipment vendors and gas and electric industry is vital.

Important areas for Research, Development and Demonstration (R,D&D) include:

- technologies to reduce the cost of distributing thermal energy;
- advanced chiller technologies including heat-activated chillers and ammonia chillers;
- advanced cogeneration district energy systems; and
- renewable-energy district energy systems.

6.2.13.2 Getting Specific

Combined cycle coal gasification is the coal technology of the future and its emission characteristics are such that it can be located fairly close to urban centers. In combination with fuel cell technology, coal gasification promises to be an exciting, near-term solution to Canadian urban community energy use for both heat and electric power. Compact, quiet, highly efficient, and exceptionally clean, fuel cell modules can be installed as needed on available urban sites, without the need to invest in large remote power plants and upgraded transmission lines. In addition, they respond well to load changes, can be used to correct power factor degradation in the urban grid, and offer considerable flexibility in the choice of fuel.

Recommendations

As recommended in previous CERI studies and presentations, more research should be directed to fuel cell commercialization and demonstration in Canada. The applications investigated should be broad-based because fuel cells have important applications for heating, cooling, electricity generation and transportation--both urban and inter-city. The Toronto Special Committee on the Environment recommends that this be taken immediately under the auspices of Toronto Hydro, Ontario Hydro and Consumer's Gas.

6.2.14 If We Do Nothing Else

Making Canadians aware of district energy and its many benefits through broad-based marketing and demonstration programs is essential. So to is the need for a new regulatory process and planning regime--one that can manage the many tradeoffs involved in assessing energy-environment-economy impacts. Unless an **Integrated Resource Planning** regime is implemented, Canada's energy situation cannot be expected to change. **District energy will never reach its potential, and the energy efficiency, environment, and economic benefits which it promises will never be realized.**

APPENDIX A

COMMUNITY INTEGRATED ENERGY SYSTEM PLANNING

Appendix A

COMMUNITY INTEGRATED ENERGY SYSTEM PLANNING

A.1 Community Integrated Energy Systems (CIES) Planning

As with any major part of the infrastructure of an urban area, district energy cannot be thought of as an independent project whose feasibility is solely dependent upon technical and economic parameters. To be successful, district energy must become an integral component in community planning, design, and development. For example, by expanding a community's comprehensive planning to include heat planning, a community can create a land-use framework that is more energy-efficient and at the same time more conducive to CIES.[1]

While access to inexpensive energy historically allowed most Canadian communities to develop with little regard for energy efficiency, during the 1970s rapidly inflating energy prices focussed attention on achieving an improved balance between energy supplies and demands. The environmental demands of the 1990s are necessitating a similar, broad-based strategy for greater end-use energy efficiency.

Such an improvement can be realized through more efficient land use patterns that require lower amounts of energy input for such functions as space heating and transportation and more efficient infrastructure design that facilitates the utilization of alternative energy resources such as renewable and waste heat, and alternative energy technologies such as district energy.

A majority of a community's energy needs are often required for heating and cooling purposes, including space and domestic water heating, industrial process heat and air conditioning in office towers and buildings. Thus, significant improvements in a community's future energy efficiency will depend in large part on orderly and timely plans for managing heat and cooling supplies and demands in such a way that total energy input is reduced. This can be achieved by energy conservation, higher efficiency of fuel utilization as can be achieved through combined heat and power (cogeneration), or the use of waste heat. In addition, a community's dependence on outside fuel supplies can be greatly reduced through the use of renewable energy resources such as biomass and geothermal, through the implementation of municipal solid waste (MSW) incineration systems, or the use of energy available at sewage treatment facilities.[2]

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[1] Gordon R. Bloomquist, John T. Nimmons and Kevin Rafferty, *District Heating Development Guide, Legal, Institutional, and Marketing Issues, Volume 1*, p. 8.

In Europe and Scandinavia, heat supply planning is not only considered a good idea, it is a national priority--often, in fact, mandated by law. In Sweden, a National Energy Policy was adopted in 1975 and in 1977 local governments were given the responsibility for energy planning (see Part II).

A typical local energy plan must contain:

- a conservation component;
- a supply component for gas, electricity and CIES;
- an analysis of the interaction between energy planning and physical planning; and
- a specific plan of action.

In Denmark, the Parliament passed the Heat Supply Act in 1979. The purpose of the Act was to reduce Denmark's dependence on oil and to secure the most cost-effective use of energy for heating purposes. The aims of the Act were to be achieved primarily through an extensive conversion from individual to public heat supply wherever it was found to be economically advantageous. To achieve these aims, **the Danish government can, in fact, require local authorities to initiate the necessary planning and carry through specific projects. The local authorities can, in turn, require consumers to join the public CIES.**

Consumers are, however, involved in the heat planning process. Public hearings are mandatory, both in the planning stage and in the subsequent implementation phases.[3]

To ensure that regional and community heat planning takes place in a coordinated fashion, close cooperation among local, regional, and central authorities is imperative. The central Danish government, therefore, is responsible for setting general guidelines for heat planning and for ensuring that the actual planning takes place in accordance with those guidelines. **The task of the local authority is to map local heat supply conditions, work out proposals for future heat supply, and to consult with consumers, supply companies, and regional authorities about the plan.**

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[2] Ibid., p. 9.
[3] Ibid., p. 10.

Although comprehensive community heat planning is a relatively recent activity in both Denmark and Sweden, major results have already been achieved. In Sweden, the country's dependence on foreign oil for heating proposes has fallen by nearly 80 percent and district energy now supplies almost 40 percent of the country's heat energy. **Denmark**, that was 95 percent dependent upon foreign oil for energy in 1972, is expected to cut that dependence to less than 30 percent by 1995. As of 1989, 44 percent of the heating requirements in Denmark were met by CIES (see Part II).

As has been demonstrated in Scandinavia, in order to best manage community energy supplies and requirements, a heat plan should be formulated and implemented as an integral part of a community's overall planning and development strategy.

Such a heat plan should be concerned with the following:

- Systematic monitoring of current and forecasted heat supplies and demands.
- Conservation of heat through more rational and efficient land use and building standards, and utilization technologies.
- Development of alternate heat resources such as biomass, geothermal, cogeneration, waste recovery, and industrial waste heat utilization.
- Optimizing the locational matches between heat sources and uses.
- Integration of heat supply and demand planning with other traditional community planning sectors, such as housing, transportation, and employment, in order to make thermal energy a key determinant in the community development process.
- Reduction of the gross fuel requirements of the community through the cumulative efforts of heat plan implementation.

Community heating and cooling loads are a direct function of land uses. The types, locations, densities, and mix of land uses will determine the suitability for district energy. Moreover, land use locational relationships to energy resource sites will determine the suitability of community heat sources for district heating and cooling.[4]

A community plan for the purposes of district energy must, therefore, be concerned with thermal resources and thermal loads and their locational relationship to one another. Thus, as thermal resource and load data is acquired it should be plotted on a map or a series of map overlays for analysis.

A.1.1 Thermal Resources

The thermal resources of the community include conventional fuels already in use and alternative energy resources that offer the potential for use. This portion of the planning process is concerned with determining which specific fuels and thermal resources are or could be available to the community; in what quantities, qualities, and locations they occur; and what their likely future prices will be (see Tables A.1, A.2, and A.3). This fuel and resource inventory should also indicate the types of alternative energy technologies that could be integrated with community infrastructures within a CIES.

The thermal resource inventory can be prepared with information from local utility officials, fuel distributors, industrial plant operators, and previous energy studies for the area. Information concerning the availability and cost of such resources as biomass and waste resources may be harder to come by and may require the services of an energy resource company that specializes in this type of resource estimation.

The thermal resource inventory will serve as the basis for future planning efforts that concentrate upon more efficient fuel use in terms of increased use per unit of energy input. The thermal resource inventory will also provide information that, when integrated with that acquired during the thermal load inventory, will serve to determine the specific locational limitations of future district energy systems.[5]

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[4] Ibid., p. 11.
[5] Ibid., p. 13.

TABLE A.1

CONVENTIONAL HEATING FUELS INVENTORY

Fuels to be Inventoried	Data to be Collected for Each Fuel
Electricity	Number of distributors
Fuel oil	Total annual energy sales
Natural gas	Estimated market share
Propane or bottled gas	Service area boundaries
Coal	Current unit cost
	Conversion to MMBtu cost
	Estimated cost inflation rate
	Conversion efficiency

SOURCE: Gordon R. Bloomquist, John T. Nimmons and Kevin Rafferty, *District Heating Development Guide, Legal, Institutional, and Marketing Issues, Volume 1* (Olympia, Washington: Washington State Energy Office, October 1988), p. 14.

TABLE A.2

RENEWABLE ENERGY INVENTORY

Resource	Data to be Collected
Hydrothermal	Site name
Geothermal Resources	Areal location
Groundwater	Areal extent
Surface water	Depth to aquifer(s)
Municipal Waste Water Effluent	Temperature
	Flow rate/aquifer drawdown
	Fluid quality
	Cost of drilling wells
Biomass	Source(s) (name, location)
Municipal Solid Waste	Type (woodchips, straw, MSW, etc.)
Forest Product Waste	Quantity (daily, annual)
Crop Residue	Quality (heat content)
	Long-term availability
	Cost (purchase, hauling)

SOURCE: Gordon R. Bloomquist, John T. Nimmons and Kevin Rafferty, *District Heating Development Guide, Legal, Institutional, and Marketing Issues, Volume 1* (Olympia, Washington: Washington State Energy Office, October 1988), p. 13.

TABLE A.3

COGENERATION AND WASTE HEAT INVENTORY

Resource Type	Data to be Collected
Power Plants	Name, location, and operating utility Prime mover type Fuel Operating mode (baseload, cycling, peaking) Present or planned generation capacity (MWe) Potential thermal capacity (10^6 Btu/hr) Retrofitted generating capacity (MWe) Start-up or retirement date
Industries	Name, location, standard industrial classification Age Annual, seasonal, & daily operating hours of plant Fuel(s) purchased (type and amount) Plant heating system type(s) System capacities and usage Amount of exothermal/liquor recovery Amount of heat losses (gas and water streams, cooldown) Amount of recoverable loss (quantity and temperature) Time-based availability of waste heat
Incinerators	Name, location, operating entity Capacity (tons/day) Potential heat production (10^6 Btu/hr) Start-up or retirement date Time-based availability of heat

SOURCE: Gordon R. Bloomquist, John T. Nimmons and Kevin Rafferty, *District Heating Development Guide, Legal, Institutional, and Marketing Issues, Volume 1* (Olympia, Washington: Washington State Energy Office, October 1988), p. 14.

A.1.2 Thermal Load

A detailed assessment of thermal load must include all thermal energy required to meet space, water, and industrial process heat and cooling demands. These heat demands should be inventoried according to sector, e.g., residential, commercial, institutional, and industrial. The objective is to establish a data base of existing and future thermal needs. A secondary objective is the identification of heat users in each sector who have a favourable potential for using district heating.[6]

Ideally, thermal load data should be based upon an audit of every building in the area. However, it is often impractical to obtain such information directly and a method of estimating thermal load from building type, age, construction, and floor space will normally have to suffice.

One such methodology for estimating thermal load has been developed by the Washington State Energy Office (WSEO) and has been incorporated into the computer program HEATMAP. Both the user manual and computer program are available from WSEO. Energy, Mines and Resources Canada (CANMET) is working with WSEO to modify this program for CIES evaluations in Canada.

The thermal load inventory will provide information critical to determining whether or not district energy could be technically and economically viable and for developing a strategy for improving community energy efficiency and district energy compatibility through land use planning.

Thermal load density (load per unit of land area), which can be determined from the thermal load inventory, is critical to the feasibility of district energy because it is one of the major determinants of the distribution network capital and operating cost. Given the high share of the distribution system in total system costs, it is imperative that communities that hope to develop district energy systems possess a sufficiently high thermal load density to support such a system.[7]

A major obstacle to reaching district energy level thermal load density is often found in urban land use plans and regulations. These controls, embodied in comprehensive land use plans, zoning and subdivision ordinances, are often inconsistent with the thermal load density, load factor, and resource/load proximity prerequisites of modern district energy systems.

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[6] Ibid., p. 15.
[7] Ibid., p. 15.

The thermal load density of a community is determined by the type and arrangement of its land uses in each neighborhood; the space and water heating loads per unit of building floor space of each neighborhood; the total amount of such floor space in each neighborhood; and any local industrial process heat loads.

As can be expected, the type and special arrangement of a community's land uses has a direct effect on thermal load densities. District heating favourability based upon thermal load densities (Table A.4) has been determined from studies in Sweden and the United States.

In addition to thermal load density, a community's load factor is a major determinant of district energy feasibility. Load factor is the ratio of total annual energy use to the total possible annual consumption if the peak were supplied continuously for a year. As with thermal load density, a high load factor is critical. A high load factor can be most easily obtained through a pattern of mixed land uses. For example, an area that is comprised of both commercial and residential units will have a higher load factor than will either land use separately. **Obtaining a high load factor through mixed load uses has been the key to the success of many European and Scandinavian district heating systems.**[8]

> "Communities have used zoning ordinances since the early twentieth century to guide growth and development. Today a community's comprehensive plan provides general land use guidelines while zoning ordinances are used to implement the plan through specific regulatory measures. Zoning ordinances not only specify that land uses can occur in a neighborhood, but also the maximum allowable density of such land uses. In residential neighborhoods, density is frequently controlled through minimum allowable lot sizes for dwelling units, or in some communities maximum allowable ratios of land area to floor space. Commercial density is often controlled by increments of allowable intensity of use. Commercial densities are also affected by off-street parking requirements and building height limitations. Industrial land uses are generally regulated on the basis of intensity, most commonly

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[8] Ibid., p. 17.

TABLE A.4

FAVOURABILITY BASED ON THERMAL LOAD DENSITY

Type of Land-Use[a]	Thermal Load Density[b] (MMBtu/hr/acre)	Desirability for District Heating
Downtown; high rises	Greater than 0.97	Very favourable
Downtown; multi-storied	0.70-0.97	Favourable
City core; commercial buildings & multi-family apartments	0.28-0.70	Possible
Two-family residential	0.17-0.28	Questionable
Single-family residential	Less than 0.17	Not possible

SOURCE: Gordon R. Bloomquist, John T. Nimmons and Kevin Rafferty, *District Heating Development Guide, Legal, Institutional, and Marketing Issues, Volume 1* (Olympia, Washington: Washington State Energy Office, October 1988), p. 13.

[a] Land-use types are categorized to indicate general groups of desirability; local land-uses may have differing thermal load densities and district heating desirabilities. For example, improvements in distribution economics may make certain single-family areas eligible for district heating.

[b] Based on diversified peak hourly load.

> through the segregation of small, enclosed uses from large, open-air uses."[9]

In addition, Canadian zoning has usually precluded mixed land uses within a single zone thus limiting diversity and load factor.

Although most cities have land use patterns and densities that are well established, significant portions of each community are subjected to current standards when development of older areas, infilling of vacant leap frogged land, or new fringe development occurs. It is, thus, essential that thermally efficient standards be adopted. Such standards should strive for both a high thermal load density and a high thermal load factor.

The following is a list of measures that the Washington State Energy Office suggests communities should consider to improve the potential for district energy.

A.2 Local Planning Measures for Improving District Energy Potential

A.2.1 Comprehensive Plan

- Amend the Comprehensive Plan to incorporate a district energy section or element. Such an amendment will signify the importance of district energy and service to the community, and provide a policy framework to guide the nature and extent of future community actions.

- A district energy element in the Comprehensive Plan should include the following:

  - documentation of the alternate heat source potentials estimated to be available to the community over time, including probable source locations and needs for site protection;

  - documentation of the community's various demands for heat and cooling, e.g., residential, commercial, industrial;

  - evaluation of alternative courses of action to assure resource conservation, and economic and social gains through resource development;

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[9] Ibid., p. 17.

  - establishment of policies to guide heat source conservation and district energy development according to preferred alternatives; and
  - identification of implementation measures, such as zoning and subdivision regulations, that can achieve policy objectives in the day-to-day community development process.[10]

- Amend the land use plan to identify the most favourable heat source areas, and designate them as significant resource sites requiring special development standards for future uses, so as to assure protection of the resource's long-term productivity by preventing development of conflicting uses.

- Amend the land use plan to designate areas for uses in proximity to heat sources according to the relative heating demands of the land uses, such that the more heat-intensive uses are located closest to heat sources wherever practical.

- Prohibit strip or linear commercial development that decreases load densities and increases distribution requirements for district energy.

- Discourage annexation and development of energy-inefficient strips or fringe areas that contribute to sprawl and low densities; encourage in-filling of vacant interior lands in targeted thermal zones.

A.2.2 Zoning Ordinance

- Amend the zoning ordinance to address four issues critical to district heating: density, diversity, rate of growth, and site standards. Also adopt zone changes consistent with land use plan changes described above.

- Create a district energy (DE) overlay zone. This zone would encompass the boundaries of those neighborhoods considered for ultimate inclusion in a district energy system, regardless of their underlying zones, i.e., residential, commercial, or industrial. Special district energy measures would be applied through this overlay zone.

- Establish a minimum density standard and density bonus. Within the DE overlay zone, all uses would be required to meet a minimum thermal load density. This would assure that new or redevelopment would result in heating loads that could be economically served by district energy. Also, bonuses could be awarded to new or redevelopment that provides above average thermal load density or an above average load factor. Bonuses could take the form of increases in maximum density limits, reduced off-street parking requirements, relaxed height limits, tax abatement, etc.

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[10] Ibid., p. 18.

- Allow mixed uses in one area so as to increase heating load diversity, and thereby increase the area's load factor. Within the district energy overlay zone, uses not otherwise permitted in the underlying zone should be allowed conditionally, if they can contribute **significantly** to an increased load factor for the immediate area, while still remaining compatible with immediately surrounding uses. Bonus incentives for mixed use developments could also be effectively offered through a planned unit development zone.

- Increase the rate of new growth or redevelopment in district energy target areas. Areas that will benefit the most from land use incentives are:

  - the principle heat source sites;
  - major pipeline corridors;
  - economic development areas or industrial parks; and
  - areas that do not presently meet minimum thermal load densities for district heating.

  These types of target areas can be delineated within the district energy overlay zone, and additional development bonuses offered to new or redevelopment that locates within such areas. Bonuses could take the form of additional reductions or variances in other non-energy standards while still maintaining compatibility with surrounding uses.

- Amend zoning performance standards to require reasonable exterior or service line access to building heating equipment, so as to facilitate future retrofitting to CIES.

A.2.3 Subdivision Ordinance

- Amend the easement authority to specifically include easements for heat source operations and district energy pipelines and facilities.

- Amend lot and block design standards to encourage district energy-oriented design, e.g., clustering. Bonuses for such designs could be offered in the form of reductions or variances in non-energy related subdivision standards.

- Amend the list of required utilities to include discretionary power for requiring district energy pipeline and/or pipeline conduit where deemed necessary for future needs.

- Designate multi-family uses to increase heat loads near heat resource sites, major institutional and commercial uses, and along district energy pipeline corridors.

- Allow alternative uses such as home occupations, or small rentals in large single-family structures, to increase residential load densities and load factors.

A.2.4 Capital Improvement Program

- Although not strictly a land use planning measure, the preparation and use of a long-range capital improvement program for a district energy system will also bolster the community's ability to optimize the benefits of the system. A carefully engineered capital improvement program can serve as an important basis for the land use measures described above, while also assuring heat source protection and system optimization.

APPENDIX B

CIES INTERVIEW RESULTS

Appendix B

CIES INTERVIEW RESULTS[1]

B.1 Interview Results

B.1.1 Overall Synopsis

Although there were no dramatic differences of views among the respondents, a variety of reactions, concerns and preferences of approach were encountered. Responses for the city of Nepean and Ottawa are provided below.

Question 1

"What do you see as the key issues that would have to be satisfied in order for you to give the CIES concept consideration? That is, having now heard about the concept and how it might be applied in this area, what questions or concerns come immediately to your mind?"

Summary of Responses

- Does it really save money?
- Will it impact on "my house" (NIMBY)
- Who puts up the money, and who gets the benefit?
- Would it have an acceptable cost/benefit? Some municipal projects such as blue boxes (recycling) have high costs, but are accepted on environmental grounds.
- Taxpayers should not be burdened, unless benefits accrue in the community.
- Sounds like something that should be done regionally, and possibly with the National Capital Commission (NCC).
- Are there good case histories to show that this really works?
- Would zoning permit plants to be built?
- Legislation in this area seems to be contrary. Should put together a review paper on applicable legislation.
- Would a co-generation plant not add to emissions locally?

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[1] This information was abstracted from a survey by Mr. Ed Lauer for CANMET, November 1991.

Question 2

"Do you think that the CIES concept would need extensive public consultation and consensus even to begin with the community energy planning step?"

Summary of Responses

- Public will have concerns about impacts on taxes and safety. Pretty essential to give public an opportunity to become informed, to head off misunderstandings, and opposition.
- Would need an overall assessment similar to environmental hearings, involving public.
- It's fundamental. Otherwise, it won't go!
- Citizen involvement in Europe is widespread and meaningful. That's why they can do these kinds of things over there. We need to encourage greater citizen participation.
- Get into groups such as the "Greenprint" committee, then get it into city official plans.
- Consultations typically bring out the activists. So you need selective consultations with key, responsible players.
- Get analysis by experts first, before exposing ideas to the public.

Question 3

"Do you think that this community puts much weight on: Improving energy efficiency and competitiveness? Helping to improve the local/regional/global environment? Boosting local economic benefits by developing homegrown energy supplies?"

Summary of Responses

- Efficiency strong, but competitiveness has little recognition.
- Environment O.K. unless direct impact on taxes.
- Homegrown energy likely accepted if explained.
- "Competitiveness" needs to be explained.
- Environmental awareness is strong, but links to efficiency and competitiveness are less understood. Energy costs are not high enough to prompt concern.
- A few in the general public understand, but most don't care.
- Sense of competitiveness is more muted than would be the case in industrial centres such as Hamilton.

Question 4

"Do you think that this community would accept increased municipal spending on alternative

energy installations, or would it tend to prefer private sector investment? What about a joint venture? What if the payout was too long for the private sector, but the project made economic sense for the community at large?"

Summary of Responses

- Wouldn't fly if taxes increased. People objected to idea of paying for garbage pick-up. $100,000 equates to three new policemen!
- People are leery about municipal involvement due to perception that governments are not competent.
- Joint venture might be O.K.
- Joint venture O.K. if community benefits are clear.
- Would the Feds take part too?
- Joint ventures don't always work. Fear of municipality getting drawn in more deeply if returns become inadequate for private sector partners.
- Couldn't finance from current city tax base - needs to be done via Region.
- We need solid evidence and thorough analysis to convince public to participate.
- Public wary of screw-ups and resulting tax hikes.

Question 5

"How do new ideas such as this one get promoted in this municipality - is it the elected officials that initiate, or do new ideas tend to come up through the professional staff? Do the elected people rely on city staff for evaluating new ideas, or do you tend to use outside consultants?"

Summary of Responses

- Innovations can originate at any level.
- Staff will have to be involved fairly early.
- Staff don't innovate much due to workload.
- Most likely need an elected "champion".
- Staff have to "buy in" otherwise will bog down.
- Elected officials promote "public" (voter) issues!
- Evaluate in-house unless insufficient expertise, then use consultants.

Question 6

"How important is it for this community to take a leadership role in promoting innovative ideas?"

Summary of Responses

- Very important. We want to lead.
- Leadership important, but public distrusts incumbents.

- Leadership is part of this city's "culture".
- Must be a regional initiative, since newer communities can collect dollars through development charges.
- Community is pretty conservative.
- Small proportion of (left wing) activists want innovative change. Most others content to follow along. Many divisive issues.

Question 7

"From what you know now, do you believe that the city administration would be prepared to hear a full presentation on community integrated energy systems, with case histories of successful projects elsewhere in North America or Europe?"

Summary of Responses

All respondents said YES.

- Should present to city committee(s) involving elected representatives plus applicable staff.
- Should be joint presentation to city and Region.
- Better to do some more sounding out of views - don't want to waste time on ideas not likely to go anywhere!

Question 8

"Do you have any other reactions or questions about this concept that Energy, Mines and Resources Canada should consider?"

Summary of Responses

- Regrets that Ontario Hydro hasn't been more active in this area.
- Incineration has to be allowed.
- Should look at whole range of possibilities, including extraction of heat from sewer water.
- Better to try in new project, rather than retrofit.
- Essential to have good public support, otherwise the NIMBY and multiple jurisdictions will kill it!
- Benefits must accrue locally!
- What are the Feds doing on this?
- Need community involvement from outset - too often Feds or province "forces" ideas on communities that can't provide the funding.
- Leitrim (Gloucester) is ideal due to prior work, close to gas line, zoning O.K., and only two players.
- Lebretton Flats development is possible, but think too many players. Would strangle it!
- Zoning and other institutional barriers would have to be cleared.

- Needs a dedicated champion, like Adam Beck (father of Ontario Hydro).
- Too little tax room in Ottawa. Got to have Regional approach.

B.1.2 Conclusions

- Community integrated energy systems concept is seen as worthwhile and desirable.

- Public concerns over high municipal taxes and skepticism over governmental involvement in new areas dictates that an effective program of public education and consultation is needed.

- Public concerns regarding specific energy projects will include the "Not In My Back Yard" (NIMBY) and safety concerns.

- Community leadership on environmental and energy efficiency issues is never-the-less desired. Community involvement in feasibility studies is likely to be accepted, and involvement in specific projects could also be accepted if the case was strong and the risks could be limited.

- Promotion of the concept is likely to be most effectively advanced by elected officials who are keen to support positive, publicly visible innovations. The support of city administrations is however essential.

- Nepean is more likely to accept a single community program than is Ottawa, the latter viewing the Regional Municipality as the more appropriate vehicle.

- A particularly attractive opportunity may exist in the Leitrim development in the City of Gloucester, where a district heating project involving energy-from-waste and natural gas has already been discussed.

- It will be necessary to expose municipal administrations to a more complete presentation of the community integrated energy systems concept with case histories detailing costs and benefits.

- All respondents cautioned against further significant burdens on tax-payers, especially if there was a danger of the city's financial involvement increasing as the project proceeded.

- Among the other barriers to community integrated energy systems were multiple jurisdictions with possible conflicting objectives, prohibitive or unfavourable legislation, and local zoning restrictions.

B.2 A Frequently Asked Question

Question: The facilities which I operate for several government departments share no serious problems with their heating system. Why should I take a risk that a major district energy project will not live up to expectations?[2]

Answer: At the operating group level within government departments, it can be expected that caution in trying a "new" technology will be exhibited. The suggested approach for overcoming this obstacle is to take the long-term view. The operating group can not be expected to become enthusiastic supporters of district systems in a short period of time. It is suggested, therefore, that a small demonstration project be identified as the first district project for implementation. Such a project would be small enough to represent little risk for proponents within the operating group but would be sufficiently large to establish credibility for at least one component of district technology. Examples of such demonstration projects would include the savings to be realized from the replacement of leaking steam distribution lines with a hot water network or the increase in boiler efficiency achievable by adding one or two buildings to an existing heating load.

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[2] Abstracted from International Energy Agency, Programme of Research, Development and Demonstration on District Heating, *District Energy Systems, Promotional Manual for System Developers and Operators*, Second Draft (November 1991), p. 59.

APPENDIX C

CANMET INTEGRATED ENERGY SYSTEM INITIATIVES

Appendix C

CANMET INTEGRATED ENERGY SYSTEM INITIATIVES

C.1 PERD/GREEN Plan Summary of Initiatives

The following is a listing of projects that are proposed by the Energy Systems Technology Group during the next two fiscal years. While some proposed initiatives may change depending on the outcome of negotiations with other partners, the list is indicative of the program priorities and the way in which the Panel on Energy Research and Development (PERD) and Green Plan projects are grouped.

C.2 Panel on Energy R&D-Fiscal Year 1991/92

C.2.1 Feasibility Studies

C.2.1.1 Deep Lake Water Cooling (DLWC)

An evaluation of the general feasibility and acceptability of a concept to cool downtown Toronto with Lake Ontario water from below the thermocline. Potential displacement of over 300 MW of electricity for driving chillers. The first phase of this work has been completed and community groups and partners have decided to proceed with more detailed work. A second phase will examine in more detail, alternatives to DLWC, specific environmental issues raised in phase 1, and certain engineering aspects that must be better defined before the project is taken to the Ontario Environmental Assessment Board by one of the partners who will become the proponent.

C.2.1.2 Kingston Public Utilities Commission/Queen's University

Evaluation in the City of Kingston of the conversion of the Queen's University district heating system to a combined heat and power system (CHP) that will be extended to serve downtown Kingston. The study was positive and the City is getting approval to proceed with detailed design.

C.2.1.3 Edmonton Power District Energy System

Edmonton Power is cooperating to explore how Edmonton can use existing institutional and University heating plants as a part of a new district energy system so as to improve the feasibility of new projects by deferring capital investment normally required for building dedicated heating or cooling plants. The Province of Alberta and the University of Alberta are contributing to this cooperative project.

C.2.2 Technology Development

C.2.2.1 Saint Mary's University

The development and testing of new friction reducing additives (FRA's) for application in Canadian district energy systems with an emphasis on niches such as low temperature cooling systems for which patents are currently being applied for. Saint Mary's University will also provide scientific support to other Canadian partners in this general initiative and assist Energy Research Laboratories (ERL) with International Energy Agency (IEA) representation in the Advanced Fluids Expert's Group.

C.2.2.2 Nova Scotia Research Foundation

Recently completed a study of the possible problems relating to corrosion protection that might arise from the use of new friction reducing additives developed under this program by Saint Mary's University.

C.2.2.3 National Research Council

A cooperative program is under way to evaluate a range of ice slurries and to resolve problems identified by Japanese partners (through SUNWELL Engineering) in branched lines and distributed storage devices. This work will form the basis for a design manual for the IEA to help accelerate the commercial application for this largely Canadian technology.

C.2.2.4 International Energy Agency

The production of a design manual for the use of ice slurries. This work includes a contract with a leading U.S. researcher who is now assisting Canada build on his past R&D in the USA.

C.2.2.5 International District Heating and Cooling Association

In conjunction with the International District Heating and Cooling Association (IDHCA), information is being gathered on actual conversion costs of buildings that connect to district heating systems. This will strengthen the utility of an earlier manual developed by ERL's partners for the IEA on guidelines for building connections.

C.2.3 Field Trials

C.2.3.1 National Research Council

The Council cooperated in testing new low temperature FRAs in one of their building cooling systems; with and without corrosion inhibitors. Friction reduction in the order of 80 percent was measured and no interference problems were observed when corrosion additives were added.

C.2.3.2 Carleton University

The University is cooperating to test new additives in their cooling system. This system is a very large ground source heat pump based network. With the cooperation of Dearborn Chemical and York Heat Pumps, heat transfer and corrosion impact will be monitored.

C.2.3.3 PEI Energy Corporation

In cooperation with the University of Dortmund, Germany and Saint Mary's University, new hot water additives will be tested in the P.E.I. systems. This cooperation is leading to more direct access to European experience in hot water FRAs exchange between universities are expected in 1992.

C.2.4 Non-technical Issues

C.2.4.1 International Energy Agency

Manuals are being prepared on the promotion and on the environmental benefits of district energy systems. This is being done with the participation of Canadian and U.S. groups and is seen as a major contribution to the better understanding of the benefits of district energy approaches at municipal, provincial and federal levels.

C.2.5 Modelling Tools

C.2.5.1 ERL Model Development

Staff and co-op students will continue the development of specialized models for the evaluation of advanced fluids technologies. These models are for evaluation of new technologies and of other commercially available software for broader total systems evaluation.

C.3 Panel on Energy R&D-Fiscal Year 1992/93

C.3.1 Feasibility Studies

C.3.1.1 Small Community Energy System Evaluations

Work will be completed on systems described above and other possible communities may be included if they offer new applications. Fernie, B.C. is a possibility. A summary design manual should be produced for such communities.

C.3.1.2 Arctic Community Energy Systems

Discussions with the Government of the N.W.T. confirm that fully integrated energy systems projects coupling CHP and district heating have not taken place because of continued use of dated high temperature district heating technology. An evaluation will be conducted in Inuvik with special emphasis on how conversions may be applied elsewhere. Other communities of interest are Iqualuit and Pond Inlet.

C.3.1.3 Advanced Fluids Evaluation

Communities having or proposing to construct district energy systems will be solicited to jointly evaluate new Canadian developed technologies including FRAs and ice slurries to evaluate the potential to improve the cost effectiveness of district energy networks. Projects will probably include Edmonton and Charlottetown. A current contract with the Lansing Board of Water and Light to evaluate the potential benefit of these technologies will provide a good basis for this work.

C.3.2 Technology Development

C.3.2.1 Perfection of Advanced Fluids Technology

Based on current field trials and laboratory testing, specific aspects will be further evaluated. High priority areas include the mitigation of heat transfer losses due to turbulence reduction by FRAs, ice slurry behaviour in heat exchangers and branched lines, ice slurry metering and control.

C.3.2.2 Application of Storage in District Energy Systems

Analyses will be performed to establish the benefit of distributed storage to provide load management in district heating and cooling systems. Partners will include Oak Ridge, Batelle and Argonne National Laboratories, and Canadian District Energy Utilities.

C.3.2.3 Multi-utility Telemetry Components

Based on 1991 work, some specific components to facilitate the gathering and transmission of system information will be required to facilitate remote meter reading, performance monitoring and load control. This will be largely paid for by industry as ESTI is serving principally as a project leader and coordinator.

C.3.2.4 Novel Heat Exchange Technology Application

Several energy opportunities for waste heat utilization have been lost as suitable low-cost heat exchangers have not been available. Recent breakthroughs by ALCAN in potential mass produced aluminum plate heat exchangers promise to open up several new applications including mine ventilation air heat recovery and ammonia or organic Rankine (bottoming) cycles. The technology is also being evaluated for other applications such as the more cost effective manufacture of ice slurry generators. Heat transfer work will be conducted in cooperation with National Research Council (NRC) and other partners such as Ontario Hydro and SUNWELL Engineering. Work is also proposed in the area of direct contact heat transfer (gas to liquid) for district cooling, ice slurry generation and low grade heat recovery from contaminated heat sources.

C.3.3 Field Trials

C.3.3.1 Advanced Fluids/Ice Slurries

Based on laboratory work, it is hoped that a full scale field trial can be attempted using ice slurries for district cooling. If evaluations of the ERL systems are positive, a project may be implemented at the CANMET laboratory. This would accelerate the adoption of these Canadian based technologies. Expected partners are SUNWELL Engineering and Ontario Hydro, the latter because of the local management benefits.

C.3.4 Model Development

C.3.4.1 ERL Modelling Capability Development

Based on evaluations in FY 1991/92, models will be acquired and tested by ESTI staff. This will allow staff to provide more comprehensive evaluations for new systems and the impact of new technologies. Cooperation is being established with the Washington State Energy Office and the U.S. Department of Energy to refine models that facilitate the evaluation of the environmental impact of the application of district energy technologies.

C.3.4.2 Second Law Analysis

Detailed evaluations will be conducted to establish the value of incorporating second law principles (energy, availability analysis) into district energy or community energy systems.

C.4 Green Plan-Fiscal Year 1991/92

C.4.1 Feasibility Studies

C.4.1.1 Canadian Energy Research Institute (CERI)

An evaluation is being conducted of policies to overcome existing barriers to greater district heating and cooling project implementation in Canada. This study will emphasize energy and environmental benefits of community integrated energy systems.

C.4.1.2 Canadian Electrical Association (CEA)

A jointly funded study examines the conditions under which it might be attractive (for economic, environmental and other reasons) for Canadian electric utilities to sell heat to district heating utilities. The study will also examine `the feasibility of converting existing generation facilities to CHP and the construction of smaller CHP stations located closer to heating loads. The report will discuss siting policy for future thermal electric generation. This cooperative project is seem as a possible turning point for Canadian utilities in their consideration of total energy rather than electric only production. The contractor for this work is FVB/ELTEC--a consortium of FVB Engineering of Sweden and Edmonton Power.

C.4.1.3 Canadian Electric Association

A second joint project is under way to compile European policy on pricing of heat and electricity from CHP units. The project will also examine those policies that might create a more favourable environment for CHP and district energy systems.

C.4.1.4 Small Communities Systems Development

Small communities including Springhill, Nova Scotia; St. Felicien, Quebec; Ouhe Bourgoumou, Quebec; Field, British Columbia and possibly Rossdale, Alberta will be evaluated to see if district heating service based on biomass boilers, CHP or on mine water heat pumps can be cost effective. The site evaluations will be conducted to establish a basis for a small community energy systems design manual. A Swedish engineering group is involved to assure that advantage is taken of the best emerging technology.

C.5.1 Industrial Applications

C.5.1.1 Cogeneration for Enhanced Oil Recovery (EOR) Projects

A joint study with AOSTRA, Alberta Power and several industries examines the opportunities for cogeneration of electricity and steam for EOR. Similar work in the U.S. will be evaluated and projects simulated in Canada. Enhanced oil recovery-based CHP could provide a very large fraction of Alberta's proposed generation requirements if feasible. The contractor is CH_2 Hill Associates.

C.5.1.2 CHP Retrofits to Institutional Heating Systems

A cost shared study with Gaz Metropolitain will examine the retro-fit of a small (<1 megawatt) cogeneration unit into a Montreal area hospital. This will serve as a good model for the many similar applications across Canada.

C.6 Green Plan–Fiscal Year 1992/93

C.6.1 Feasibility Studies

C.6.1.1 ERL–The Showcase Facility

Staff evaluations indicate a good potential for cogeneration, medium or low temperature district heating conversion, district cooling and integrated heat recovery for pilot plant operations and ventilation air. Economic feasibility studies will be completed that detail desirable or feasible conversions and the potential to use ERL heating or cooling load to "host" cogeneration devices.

C.6.2 Industrial Applications

Based on PERD supported work for mine water heat recovery and earlier work for geothermal heat recovery distribution, a manual will be prepared that specifically identifies the opportunities to recover heat within industrial operations and transport it to local municipalities for space heating or cooling. This work will attempt to dispel current myths about feasible distances for heat transport that have limited development of efficient energy options.

C.6.3 Technology Development

C.6.3.1 Arctic Community Energy Systems Infrastructure

Evaluations will include novel approaches to integrating district heating, sewer and water services that might be more attractive and efficient than the currently used utility or systems. This will be based on earlier technology developed with the Institute for Research on Construction (IRC) of NRC that protects permafrost with ground source heat pump technology and permits slab on grade construction techniques.

C.6.4 Field Trials

C.6.4.1 Novel Power Generation Cycles

If work with Ontario Hydro, Alcan and GEC Marconi (UK) is successful in 1991/92, pilot scale trials of an ammonia or organic Rankine cycle electricity generator is probable. This might be at an Ontario Hydro generating station or a steel industry with whom Ontario Hydro negotiating.

C.6.4.2 Low Cost Distribution Piping Technology

International Energy Agency work has identified several promising non-metallic piping technologies for significantly decreasing the cost of low energy density systems. Depending on the level of confidence, test units might be installed either at ERL or in a small community identified through other studies.

C.6.5 Non-technical Issues

C.6.5.1 Knocking Down the Barriers

Based on earlier promotional and institutional work, a pro-active initiative will be developed to prepare materials that address reservations or information gaps regarding integrated energy systems technologies. Energy Systems Newsletters and targeted information dissemination will be well under way as will improved public enquiry response.

C.6.5.2 Community Energy Systems Plan "Competition"

Discussions with several provinces and utilities shows a high level of interest in this concept. European experience confirms that the requirement for community energy systems plans tend to lead to implementation. A program of information dissemination followed by a competition either on a national or provincial basis will be launched. We have already established a working relationship with the Canadian Urban Institute and the Canadian Federation of Municipalities who are most enthusiastic about promoting such a program.

C.6.5.3 Preliminary Feasibility Analyses for Communities

With the Washington State Energy Office, ESTI is arranging for the evaluation of the HEATMAP models to undertake preliminary evaluation of communities for the application of community energy systems such as district heating and cooling, CHP and related technologies such as central biomass or refuse-based heating plants. Preliminary discussions with an engineering association indicate that a cooperative program might be developed, possibly including universities, to conduct preliminary evaluations that would stimulate projects at the municipal level.

C.6.6 Model Development

C.6.6.1 Regional Impact Modelling

With the IEA and the Washington State Energy Office (WSEO), existing community based models will be refined to predict regional impacts and benefits based on the application of community integrated energy systems with various assumptions regarding fuel types and technologies for existing and proposed systems. Discussions with Environment Canada and WSEO suggest that this capability is feasible and desirable as an energy/environmental planning tool. A user friendly model is seen as an important promotional tool that will enable municipalities and their consultants to appreciate the merits of community/regional integrated resource planning.

APPENDIX D

HEATMAP

Appendix D

HEATMAP[1]

D.1 A Computerized Tool For Analysing District Heating and Cooling System Feasibility

- HEATMAP enables district energy professionals to:
  - analyse feasibility of proposed systems
  - track performance of existing systems
  - assess expansions to existing systems
  - evaluate hot water, steam, and chilled water distribution systems
  - determine environmental benefits

- What Can HEATMAP do?

Uses comprehensive defaults to calculate:

- heating and cooling load for potential system consumers
- size and cost of distribution system
- optimum production plant sizes and costs
- delivered cost to consumers for heating and cooling

Enabling you to get results without gathering extensive data

- Establishes and maintains a database describing:
  - consumer heating and cooling loads
  - air emissions
  - production plants
  - distribution system
  - economics

Providing you with easy access to information

- Tracks detailed information about each consumer including:
  - HVAC equipment
  - energy use
  - ownership and operation

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[1] CANMET is currently working with the Washington State Energy Office to make this model appropriate to Canadian urban and regional CIES evaluations.

Allowing you to analyse system performance and project consumer loads

- Calculates potential environmental factors including:
    - air emissions
    - fuel use

Enabling you to compare environmental impacts of district systems to traditional systems

- Links the database to the project map

Enabling you to access database information by locating a facility on the map.

How does HEATMAP work?

Conveniently integrates industry-standard software:

- AutoCad by AUTODESK, Inc.
- LFLOW-2F by LIConsult

Into a single package

Uses pull-down menus and provides on-line help

Operates with English or metric units-both units are available

- What are HEATMAP's system requirements?
    - IBM compatible 386 PC
    - math coprocessor
    - mouse or digitizing tablet
    - autoCAD
- HEATMAP's users and sponsors
    - Washington State Energy Office (coordinator)
    - New York State Energy Research and Development Authority
    - United States Department of the Navy
    - United States Department of Energy
    - Swedish Council for Building Research (BFR)
    - Swedish Trade Office (SWEBEX)
    - City of Chicago
- HEATMAP's Contractors
    - T+VE, Stockholm, Sweden

- Criterion, Portland, Oregon
- LIConsult, Birkerod, Denmark

- For more information contact:

Richard Been
Washington State Energy Office
809 Legion Way S.E. FA-11
Olympia, Washington 98504-1211
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D.2 Overview

HEATMAP is a computerized tool intended to provide a fast and reliable means of describing and analysing a district heating and cooling (DHC) system. Although its primary purpose is to assist engineers and planners in assessing the economic feasibility of a proposed DHC project, the software may also be used to model existing systems.

The HEATMAP program allows the user to establish and maintain a project database that stores a structured, detailed description of the target DHC system. The database and the HEATMAP software are organized to correspond the six general categories of information and function that are required to complete a DHC project:

(1) general project description
(2) consumer heating and cooling loads
(3) production plants
(4) distribution system
(5) economics
(6) library (support data)

The user directs the operation of the program using a hierarchical system of menus. A menu bar is always present at the top of the screen. The menu presents the user with six options, corresponding to the six functional categories listed above. When the user selects an option, the program presents a subsidiary pulldown menu from which actual program functions are invoked (e.g., data entry or printing reports).

The HEATMAP database is linked to a project map that is constructed using computer aided design (CAD) software. The location of each DHC consumer and production plant in the database is identified on the map. The map also contains a representation of the distribution network. Each node and pipe depicted on the map is linked to a corresponding record in the project database.

APPENDIX E

CONTACT LISTING

Appendix E

CONTACT LISTING

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MUNICIPAL

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International District Heating and Cooling Association
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APPENDIX F

AN OVERVIEW OF DISTRICT HEATING LEGISLATIVE AND REGULATORY FRAMEWORKS IN ONTARIO

Appendix F

AN OVERVIEW OF DISTRICT HEATING LEGISLATIVE AND REGULATORY FRAMEWORKS IN ONTARIO[1,2]

F.1 Introduction

This "mini-review" of district heating legislation and regulatory frameworks in Ontario has been prepared at the request of the Canadian Energy Research Institute (CERI). It is intended as a general guide, and not as a checklist of legal and regulatory requirements. Interested parties are advised to seek legal advice on applicable legislation and regulations in their areas and to consult with appropriate government regulatory agencies.

F.2 Administrative Structures and Legislation Governing Provision of Service

District Heating is a public utility service which may be supplied by a public, private or special purpose body.

A district heating system may also supply the distributed energy needs of a single, public or private organization (e.g., a university).

Examples of some actual and hypothetical structures for district heating utilities are shown in Table F.1, together with applicable legislation.

The range of utility structures illustrated encompasses private, profit making corporations to dedicated, non-profit special purpose bodies.

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[1] R. Higgin, Deputy Commissioner, Environmental Services Division, City of Toronto, Department of Public Works and the Environment, January 17, 1992.

[2] The views represented in this paper are those of the author and do not necessarily represent the position of the City of Toronto or its Department of Public Works and the Environment. No claim is made with respect to the accuracy of the information and the reader is advised to seek professional advice on matters addressed in this paper.

TABLE F.1

SOME SAMPLES OF DISTRICT HEATING UTILITIES AND APPLICABLE LEGISLATION

Type of Entity Actual or Theoretical	Type	Applicable Provincial Legislation
Toronto District Heating Corp. (A) TDHC	Special Purpose Municipal	Toronto Hospitals Steam Corp. cont'd TDHC[a] (OEB Act)[b]
Toronto Hydro (A) (sold assets to TDHC in 1975)	Public Utility	Public Utilities Act (OEB Act)[a]
University of Toronto (A)	Special Purpose	**Exempt** - Supplies University Bldgs.
Gas Utility (T)	Gas Utility Owned Public Utility	Public Utilities Act (OEB Act)[b]
XYZ Corp (T)	Privately-owned	Public Utilities Act (OEB Act)[b]
Public Works Canada (Ottawa) (A)	Federal Dept.	**Exempt** - Supplies Federal Bldgs.

In addition, all entities which supply and sell energy from any source are required to have a municipal franchise and a certificate of public convenience and necessity pursuant to the Municipal Franchises Act

SOURCE: R. Higgin, Deputy Commissioner, Environmental Services Division, City of Toronto, Department of Public Works and the Environment, January 17, 1992.

[a] The rates of TDHC are set by its Board. The legislation provides that any appeal of rates or conditions or service can be made to the Ontario Energy Board.

[b] Public and private utilities, unless otherwise exempted, are subject to the Public Utilities Act. Rates may also be regulated by the Ontario Energy Board. In the case of an electric utility which also operates a district heating system, the rates are also subject to approval by Ontario Hydro.

Unless otherwise exempt by virtue of their constitutive legislation, district heating utilities in Ontario are subject to the Public Utilities Act and also require franchises and certificates of public convenience and necessity under the Municipal Act.

F.3 Rate Regulation

The rates charged for district heating service fall under provincial regulation if the entity is either a privately-owned utility, or if the legislation establishing the utility requires this. In addition, for regulated utilities, the capital investment and fuel contracts are subject to review and tests of prudence by the regulator. In Ontario, the applicable regulator is the Ontario Energy Board.

Currently, there is no regular OEB review of district steam rates such as those of Toronto District Heating Corporation (TDHC). The rates of district heating utilities are approved either by the utility's Board of Directors or the Board of its parent body.

F.4 Taxable Status

The majority of the district heating utilities listed in Table E-1 would be classed as public, not for profit, corporations. If a gas utility-owned or other private sector utility were established, it would be subject to provisions of the Income Tax Act as applicable to Corporations.

Public bodies may also be exempt from the Federal Goods and Services Tax. The Goods and Services Tax (GST) would not be charged on the service rates and the public, non-profit entities could receive a credit in respect of GST paid on goods and services purchased (e.g., fuel). Private district heating utilities would be subject to all GST provisions.

Individual GST status would be determined by Revenue Canada based on information supplied by a district heating utility.

Provincial and Federal Sales Taxes would apply to all goods and services purchased, regardless of ownership structure, unless the utility is specifically exempt by virtue of its constitutive statute.

F.5 Access to Capital Markets

Borrowing by public sector district heating utilities is usually subject to approval of their parent bodies and/or senior levels of government. The Toronto District Heating Corporation, for example, must rely on the City of Toronto to raise debt capital on its behalf. The University of Toronto requires provincial approval of its capital budget including investment in its physical plant.

The hypothetical gas utility, or privately-owned utility, would access commercial debt or equity markets for its capital requirements, subject only to approval of its Board of Directors.

F.6 Public Safety and Pipeline Construction

Construction of district heating piping systems is subject to the provisions of the Municipal Act and the Planning Act in respect of easements and rights of way. In addition, the actual engineering design, construction and testing is subject to the provisions of the Energy Act and the Pressure Vessels Act which govern the protection of the public from hazards associated with underground pipelines, tanks or pressure vessels.

F.7 Expropriation Powers

Public utilities must make application to the Ontario Municipal Board, under the Expropriations Act, to expropriate private property for utility purposes. Municipal, provincial and federal governments and their Boards and agencies including Ontario Hydro are not subject to expropriation.

F.8 Environmental Legislation

District heating systems constructed by public bodies in Ontario are subject to the provisions of both the Environmental Assessment Act (EAA) and the Environmental Protection Act (EPA) and its Regulations. Private utilities generally must comply only with the provisions of the EPA and Regulations.

F.8.1 Environmental Assessment Act

Certain special purpose bodies may be exempt from the provisions of the EAA, such as is the case for TDHC. Private utilities would also be exempt from the EAA, unless a specific undertaking was designated by the Minister of the Environment.

There is no Class Environmental Assessment (Class EA) for district heating projects, unlike municipal sewer and water projects and municipal road projects. They are either exempt or not, based on the status of the proponent (public or private).

F.8.2 Environmental Protection Act

District heating utilities must comply with applicable provincial (and municipal) legislation in respect of air emissions and sewer discharges. The applicable air regulations in Ontario are set out in Ontario Regulation 308. In future, district heating utilities will also be subject to Control on Air Pollution (CAP) emission regulations (when enacted).

Regulation 308 sets the following maximum 30 minute point of impingement concentrations for the products of combustion:

SO_2	830 g/m^3
Total Suspended Particulates (<44)	100 g/m^3
NO_x as NO_2	50 g/m^3
Carbon Monoxide	6000 g/m^3
Ozone	300 g/m^3

F.8.3 Municipal By-laws

Municipal noise legislation governing allowable noise levels and operating hours may be applicable to the operations of the district heating plant and may restrict or prohibit certain operations, such as boiler blowdown, or require mitigation measures.

Municipal planning and zoning regulations may affect the construction of new or expanded heating/cooling plant by imposing compatible land use or stack height restrictions.

Zoning by-laws may not protect the air rights of existing district heating plants from encroachment unless rezoning is required and the district heating utility can oppose the rezoning or negotiate compensation. It is therefore possible for new buildings to be constructed creating a revised stack impingement zone and resulting in non-compliance with provincial air regulations.

F.9 Competition

This "mini-review" has revealed that the operations of district heating utilities in Ontario are subject to a variety of Provincial and Municipal legislation, regulations and by-laws. District heating utilities do not have an exclusive franchise to supply energy in their service area and are subject to competition from individual natural gas heating and cooling systems and, to a lesser degree, electricity (cooling) and oil systems. This review has not examined the legislature and regulatory frameworks for competing utilities and energy forms, and so no assessment can be made as to whether a 'level playing field' exists and/or whether district heating utilities are over- or under-regulated.

GLOSSARY

ACID RAIN PRECURSOR: A material such as SO_2 or NO_x which is transformed in the atmosphere to become a component of acid rain.

ACID RAIN: Rain or snow contaminated by acids formed when industrial pollutants, especially sulphur dioxide and nitrogen oxides, undergo chemical changes in the atmosphere.

ACID: A substance which dissolved in water produces a sharp, sour solution; capable of providing hydrogen ions (H^+); common examples are lemon juice, vinegar and battery acid. Acidity is expressed on a numerical cH scale. An acidic solution has a pH less than 7.0.

ACIDIC DEPOSITION: The transfer of acidic or acidifying materials from the atmosphere by dry and wet deposition of the earth.

ACIDITY: A measure of the concentration of hydrogen ions, often on a scale from 1 to 14 where 1 is very acidic, 14 is very basic (alkaline) and 7 is neutral.

AEROSOL: A suspension of fine solid or liquid particles in a gas. Smoke and fog are aerosols.

AIR TOXICS: A substance suspended in the air that has or tends to have a harmful effect on the environment or man.

AIRSHED: A geographical area containing emission sources and the ecosystems potentially affected by emissions from those sources.

ALKALINE: Containing an alkali; any substance with a pH level greater than 7.

ALTERNATIVE ENERGY/TECHNOLOGY: Energy sources or technologies which are not yet widely used, as opposed to "conventional" energy/technology. The term usually refers to renewable energy sources and small, decentralized installations. Examples are photovoltaics, solar heating, wind power and waste-fuelled electrical generation.

AMBIENT AIR: Outdoor air; all air that plants and animals breathe except the air.

ATMOSPHERE: The air surrounding the earth, consisting mainly of nitrogen and oxygen. More than 75 percent of the total mass of the earth's atmosphere is within 10 km of the earth's surface.

AVOIDED COST: The cost which would be incurred by an electric utility in providing new generating capacity if the utility were to provide the power itself instead of purchasing it from an independent generator.

BADT: Best available demonstrated technology.

BASE LOAD: The minimum continuous load over a given period of time.

BASE-LOAD GENERATING STATION: A generating station which is normally operated to supply all or part of the base load of a system and which consequently operates at full output whenever available. Base-load generating units tend to be large units with low operating costs.

BATEA: Best available, economically achievable technology.

BIOMASS, PLANT: Wood, peat and other vegetation.

BROMINE (Br): A toxic, highly corrosive gas of the same chemical group as fluorine and chlorine.

BUFFER: A chemical which, in solution, will resist changes in pH or, if added to a solution, will change the pH of that solution. In nature, limestone (calcium carbonate) will act as a buffer against Acid Rain to maintain or raise the pH of a waterbody.

CAPABILITY: The maximum load that a station or equipment is capable of carrying under specified conditions.

CAPACITY FACTOR: For any equipment, the ratio of the average load during some period of time to the rated capacity of the equipment. Capacity factor is usually expressed as a percentage.

CAPACITY: The rate of delivery of energy (for example, a utility might sell 50 megawatts of capacity or electric power) or the maximum quantity of power that a piece of equipment or a system is capable of carrying or supplying (for example, a generating unit might have a rated capacity of 50 megawatts).

CARBON DIOXIDE: A colourless, odourless, non toxic gas essential to plant and animal life and considered the major greenhouse gas. Emissions caused by natural and human factors. Volcanoes emit carbon dioxide, and major changes in global vegetation can contribute to, or withdraw from, the atmospheric carbon reservoir. Combustion of fossil fuels adds carbon to the atmosphere, as do gas flaring and cement production. In addition, carbon is released by the burning or decomposition of the biomass when forestland is cleared.

CARBON MONOXIDE (CO): A colourless, odourless, poisonous gas formed when carbon burns with an insufficient supply of oxygen. Part of the exhaust gases of automobile engines.

CASA: Clean Air Strategy for Alberta.

CCME: Canadian Council of Ministers of the Environment. The CCME is a joint council whose members include the provincial and federal Ministers of Environment. The purpose of the CCME is to jointly address environmental issues which cross provincial jurisdictional boundaries.

CH_4: See Methane.

CHLORIDE: Any of a group of chemical compounds consisting of chlorine and some other element.

CHLORINE (Cl_2): A greenish-yellow poisonous, corrosive gas used in making drugs, dyes, explosives and plastics, and in bleaching and disinfecting.

CHLOROFLUOROCARBONS (CFCs): Man-made chemical compounds containing chlorine, fluorine, and carbon. Chlorofluorocarbons (CFCs), in the form of CFC-11, CFC-12, and CFC-13, affect the climate through their absorption of infrared radiation and their reaction in the atmosphere with other chemicals. The CFCs produce a highly reactive form of chlorine, which in turn depletes the stratospheric ozone layer. In Canada, almost 70 percent of CFCs are used in air conditioning and rigid foam insulation.

CLIMATE CHANGE: Upward or downward trends in average conditions or in the incidence of weather extremes.

CO: See Carbon Monoxide.

CO_2: See Carbon Dioxide.

COAL GASIFICATION: A chemical process which converts coal to a gaseous fuel suitable for burning in fossil generating stations.

COGENERATION: The combined production of electricity and useful heat.

COMMON POLLUTANT: Pollutants historically regarded as being the most significant air pollutants and are known as the criteria pollutants at U.S. EPA (Particulates, SO_2, NO_x, CO).

CONSUMPTION: Use of electrical energy, typically measured in kilowatt-hours.

CONVENTIONAL GENERATION: Electricity that is produced at a generating station where the prime movers are driven by gases or steam produced by burning fossil fuels.

CRITICAL OR THRESHOLD LOADING: The maximum level of atmospheric deposition an ecosystem can take without being damaged.

DEFORESTATION: The loss of forests, either by tree harvesting or clearing, or through disruption of the natural balance from changes in rain, moisture, drainage or nutrient supply.

DEMAND MANAGEMENT: A set of programs and measures undertaken by electrical utilities to influence the amount and timing of customer demand for electricity. Some programs, like electrical efficiency improvements, are designed to reduce demand. Others, like time-of-use rates, are designed to shift consumption from peak to off-peak periods.

DEMAND: "Demand" is often used synonymously with "power" which is the rate at which electrical energy is being delivered.

DESERTIFICATION: The growth of existing deserts or the development of new deserts or desert-like areas.

DISTRIBUTION SYSTEM: The lines, transformers, switches, etc., used to distribute electricity or heat over short distances from the transmission system to customers.

DRY DEPOSITION: The transfer of acids and acid-forming substances to the earth's surface by all means that do not involve some form of precipitation; includes absorption, impaction, sedimentation, and chemical reaction.

ECOSYSTEM: The interaction of organisms and their physical surroundings.

ELECTRICAL EFFICIENCY IMPROVEMENTS: Measures designed to reduce the consumption of electricity while maintaining a given level of service. For example, a less efficient bulb may be replaced with a more efficient bulb which gives off the same amount of light while consuming less electricity. Also referred to as conservation measures.

ELECTRICAL POWER: The rate of delivery of electrical energy and the most frequently used measure of capacity. The basic unit is the kilowatt (kW).

ELECTRICAL UTILITY: An organization that has as its prime purpose the generation, transmission and/or distribution of electric energy for sale.

ELECTRO-TECHNOLOGY: A technology that uses electricity in its processes, especially new technologies used to displace other energy sources. An example is the use of electrically-driven heat pumps for kiln drying wood, in place of air heated by on-site fuel combustion.

EMISSION FACTOR: An estimate or statistical average of the rate at which a contaminant is released to the atmosphere as a result of some activity, such as combustion or industrial production, divided by the level of that activity. The emission factor, therefore, relates the average quantity of each contaminant emitted to an appropriate base quantity. It is usually expressed as the weight of contaminant divided by a unit weight, volume, distance or duration of the associated activity that emits the pollutants (e.g., kg of SO_2 emitted per tonne of coal combusted). Factors are usually obtained from data of varying degrees of accuracy and may be presented for either uncontrolled surfaces or facilities having air pollution control devices in place.

ENERGY SOURCE: The primary source that provides the power that is converted to electricity. Energy sources include coal, petroleum and petroleum products, gas, water, uranium, wind, sunlight, geothermal, and other sources.

ENVIRONMENT: The components of the earth and includes: (i) air, land and water; (ii) all layers of the atmosphere; (iii) all organic and inorganic matter and living organisms; and (iv) the interacting natural systems that include the components referred to in (i) to (iii) above.

EPA: United States Environmental Protection Agency.

ERCB: Energy Resources Conservation Board, Alberta.

FLUIDIZED-BED COMBUSTION: A method of combustion in which air, blown up through orifices in the floor of the firebox, suspends particles as a fluidized bed. The particles consist of fuel and a sorbent such as limestone.

FLUOROCARBONS: Man-made chemical compounds containing fluorine and carbon.

FOSSIL FUELS: The remains or traces of prehistoric plants or animals formed in the geological past and removed from the earth in the form of oil, gas and coal.

FUGITIVE EMISSIONS: Air pollution deriving from human activities that do not emanate from a particular point, such as an exhaust pipe or stack. Roadway dust and VOC from refinery valves are examples.

GCM: General circulation models. GCMs are numeric computer models that simulate the evolution of large scale weather systems including some form of the interaction between the atmosphere and the ocean.

GENERATING STATION: A station comprising one or more generating units for the production of electricity. The main types of generating stations are hydroelectric, nuclear-electric and fossil-fuelled (by coal, oil or natural gas). In some parts of the world, such as the Geysers region of California, geothermal-electric power is becoming an important element of generating capacity.

GIGAWATT (GW): One billion watts (see Watt).

GIGAWATT HOUR (GW.h): A unit of bulk energy. A million kilowatt-hours. A billion watt hours.

GLOBAL WARMING: Increase in the earth's lower atmospheric temperature, possibly the result of the greenhouse effect.

GREENHOUSE EFFECT: The phenomenon occurring when certain atmospheric gases trap radiated heat in the atmosphere.

GREENHOUSE GAS EMISSIONS: Gases like carbon dioxide (CO_2) and methane trap heat in the earth's atmosphere and are believed to contribute to global warming, the so-called "greenhouse effect."

GRID: A network of electric power lines and connections.

HALONS: Man-made chemical compounds that contain bromine or iodine.

HC: See Hydrocarbons.

HEAT RATE: A measure of generating station thermal efficiency, generally expressed as British thermal units per net kilowatt-hour. It is computed by dividing the total heat (Btu) content of the fuel burned by the resulting net kilowatt-hours of electricity generated. In metric units, the heat rate is expressed as kilojoules per kilowatt-hour.

HEAT VALUE: Low and High Heat Values. Any fuel containing hydrogen yields water as one product of combustion. At atmospheric pressure, the partial pressure of the water vapor in the resulting combustion gas mixture will usually be sufficiently high to cause water to condense out if the temperature is allowed to fall below 120 to 140 °F. This causes liberation of the heat of vaporization of any water condensed. The low heat value is evaluated assuming no water vapor condensed, whereas the high heat value is calculated assuming all water vapor condensed.

To facilitate calculations of the temperature attained by combustion, it is desirable to make use of the low heat value. The necessity of taking into account the heat of vaporization of the water vapor and the difference between the specific heats of liquid water and of water vapor is thus avoided.

The high heat combustion exceeds the low heat combustion by the difference between the heat actually given up on cooling the products to the initial temperature and that which would have been given up if the products had remained in the gaseous state. The quantity to be subtracted from the high heat value to obtain the low heat value will vary with the composition of the fuel.

HYDROCARBONS (HC): A series of compounds of hydrogen and carbon formed by the decomposition of plant and animal remains, including the several types of coal, mineral oil, petroleum, paraffin, the fossil resins, and the solid bitumens occurring in rocks.

HYDROELECTRIC STATION: An electric generating station in which the prime movers are hydraulic turbines.

INCREMENTAL GENERATING COST: The cost of generating one additional unit of electric energy above some previously determined base quantity.

INDEPENDENT (PRIVATE) GENERATION: Generation owned or operated by producers other than a utility. These producers usually have generating plants for the purpose of supplying electric power required in their own industrial and commercial operations. The term also covers private plants whose sole purpose is the sale of electricity to a utility.

INSTALLED (GENERATING) CAPACITY: The capacity measured at the output terminals of all the generating units in a station, before deduction of station service requirements.

INTEGRATED RESOURCE PLANNING: Joint planning by different power systems in order to minimize total costs.

INTERCONNECTED SYSTEM: A system consisting of two or more individual power systems or heating connected together by tie lines.

IPCC: Intergovernmental Panel on Climate Change.

JOULE: The international unit of energy. The energy produced by a power of one watt flowing for one second. The joule is a very small unit: there are 3.6 million joules in a kilowatt-hour.

KILOVOLT (kV): 1000 volts.

KILOWATT (kW): The commercial unit of electric power; 1000 watts. A kilowatt can best be visualized as the total amount of power needed to light ten 100-watt light bulbs.

KILOWATT-HOUR (kW.h): The commercial unit of electric energy; 1000 watt hours. A kilowatt-hour can best be visualized as the amount of electricity consumed by ten 100-watt light bulbs burning for an hour. One kilowatt-hour is equal to 3.6 million joules.

LEACHING: A natural process by which water dissolves minerals out of rocks. The leaching of heavy metals, such as mercury, into water supplies is believed to be a serious consequence of Acid Rain.

LIMESTONE: A sedimentary rock consisting chiefly of calcium carbonate. Limestone is an effective buffer against acid rain.

LOAD FACTOR: The ratio of the average load during a designated period to the peak or maximum load in that same period, usually expressed as a percentage of the peak load.

LOAD MANAGEMENT: The manipulation of customer demand by economic and/or technical means.

LOAD: The amount of electric power or energy consumed by a particular customer or group of customers.

LOSSES: Energy or power lost in circuits or equipment, mainly in the form of heat, when current flows through the circuit.

LRTAP: Long Range Transport of Atmospheric Pollutants (Canada). A program of federal, provincial and territorial governments in western and northern Canada to research, monitor and manage acid deposition and other atmospheric pollutants.

MEGATONNE: One million metric tonnes.

MEGAWATT (MW): a unit of bulk power; 1000 kilowatts.

MEGAWATT HOUR (MW.h): A unit of bulk energy; 1000 kilowatt-hours.

METHANE (CH_4): The most simple of the hydrocarbons; the major component of natural gas. After carbon dioxide, methane is the second largest contributor to the greenhouse effect. Most methane emissions are generated by natural sources such as decomposition of materials in wetlands and by non-energy-related human activities such as agriculture and animal husbandry. The production and use of energy account for only a limited share of methane emissions.

MILL: 1/1000 of a dollar.

MOBILE SOURCE: A segment of the area source classification representing transportation sources such as vehicles, aircraft and railroads.

MONOXIDE: An oxygen compound containing one oxygen atom in each molecule.

MONTREAL PROTOCOL, THE: An international protocol dealing with substances that deplete the earth's ozone layer. Adopted by over 40 countries September 16, 1987 in Montreal, it calls for a 50 percent reduction in chlorofluorocarbons (CFCs) and halons from the 1986 level of 1999. Canada is committed to an 85 percent reduction by the year 2000.

NATIONAL AMBIENT AIR QUALITY OBJECTIVES: Prescribed by the federal government under the *Canadian Environmental Protection Act* to reflect regional air quality goals in three ranges--"tolerable," "acceptable," and "desirable." They are not source-specific but are geographical area-specific. They are applicable to specific air contaminants. They are enforceable by the provinces once adopted by them as part of their environmental laws in virtue of a federal-provincial agreement under the federal *Canadian Environmental Protection Act*.

NITROGEN (N_2): A colourless, tasteless gas that makes up four-fifths of the earth's atmosphere.

NITROGEN OXIDES (NO_x): Formed when nitrogen (N_2) combines with oxygen (O_2) in the burning of fossil fuels and from the natural degradation of vegetation, and from the use of chemical fertilizers. A significant component of acid deposition and photochemical smog.

NITROUS OXIDE (N_20): A colourless, slightly sweet-smelling, non-toxic gas which occurs naturally in the atmosphere. Man-made nitrous oxide is used as the anaesthetic commonly called "laughing gas". Combustion of fossil fuels releases nitrous oxide, which affects the formation of ozone in the troposphere. The non-energy sources of nitrous oxide emissions, such as the use of agricultural fertilizers, are believed to be far larger than the energy-related sources. About one-third of total global N_2O emissions are anthropogenic, resulting mainly from fertilizer application and to a lesser extent from large stationary combustion sources. Mobile Sources are not significant emittors of N_2O.

NUCLEAR POWER: Power generated at a station where the steam to drive the turbines is produced by the process of atomic fission, rather than by burning a combustible fuel.

OECD: Organization for Economic Cooperation and Development.

OXIDATION: Combining or reacting with oxygen.

OXYGEN (O_2): A colourless, tasteless and odourless gas that forms one-fifth of the air and which is combined in water and most mineral and organic substances. The most abundant of the elements, it is essential to plant and animal life.

OZONE (0_3): A blush, toxic gas, with a pungent odour, formed of three oxygen atoms rather than the usual two.

PARALLEL POWER: Independent generation which is linked to and synchronized with the bulk electricity system.

PARTICULATES: Or total particulate matter (TPM) is any aerosol that is released to the atmosphere in either solid or liquid form. The upper size limit is generally regarded to be about 75 microns.

PEAK DEMAND: The maximum power demand registered by a customer or a group of customers or a system in a stated period of time such as a month or a year. The value may be the maximum instantaneous load or, more usually, the average load over a designated interval of time, such as one hour, and is normally stated in kilowatts or megawatts.

PEAK PERIOD: Periods during which relatively high demands are placed on an electrical system, as opposed to off-peak periods.

PEAKING UNIT: A generating unit intended to be operated intermittently to supply peak loads.

PETAJOULES: An energy measurement. Equals one thousand, million, million or 10^{15} joules.

pH SCALE: is used to measure acidity or alkalinity. Neutral solutions have a pH of 7, acid solutions have a pH less than 7, and alkaline solutions have a pH greater than 7. Each unit change in pH represents a tenfold change in acidity. For example, rainfall with pH 4 is 10 times as acidic as rainfall with pH 5 and 100 times as acidic as rainfall with pH 6.

POINT SOURCE: Any stationary source that usually releases emission through stacks at elevated heights for which individual source records are maintained in the inventory and for which annual emissions exceed a specified cut-off level. Although there is no uniform designated cut-off level, sources with emissions that generally exceed 100 metric tons (tonnes) per year of any one of the five common pollutants generally are included in inventories. Similarly, emission points that release greater than approximately 500 tonnes per year are regarded as major point sources.

POLLUTION RIGHTS: A system of marketable permits allowing the bearer to emit a specified level of pollutants. Under this rights system, the government controls the total level of emissions, but not the distribution of these emissions among firms.

POWER SYSTEM: All the interconnected facilities of an electrical utility. A power system includes the generating stations, transformers, switching stations, transmission lines, substations, distribution lines and circuits to the customers' premises; that is, all the facilities required to provide electrical services to the customers.

PRIMARY ENERGY SOURCE: The source of primary energy from which electricity is generated, including falling water, uranium (by nuclear fission), coal, oil, natural gas, wind, biomass, direct solar radiation, geothermal energy and tidal energy.

PRIME MOVER: The turbine or engine that drives an electrical generator.

RADIOACTIVE WASTE MANAGEMENT: All activities, administrative and operational, that are involved in the handling, treatment, conditioning, transportation, storage and disposal of radioactive waste.

RADIOACTIVITY: The property of certain nuclides of spontaneously emitting particles or gamma radiation from their nucleus, of undergoing spontaneous fission, or of emitting X-radiation.

RELIABILITY: The ongoing ability of a power system to avoid outages and continue to supply electricity with the appropriate frequency and voltage to customers.

RENEWABLE ENERGY SOURCE: A source of energy which is inherently self-renewing, such as the various manifestations of solar energy (water power, biomass, wind energy, direct solar radiation, wave energy and ocean currents), tidal energy and geothermal energy.

RENEWABLES: Renewable forms of energy production which include solar and wind energy.

RIGHT-OF-WAY: The strip of land on which a power line is located, and on which the power company has acquired the legal right to perform construction and maintenance, to restrict the growth of vegetation, and sometimes to restrict construction by other parties. The width of the right-of-way varies with line voltage.

SEASONAL DIVERSITY: The diversity between loads that reach their maximum values at different seasons of the year. For example, most Canadian power systems experience their annual peak loads in the winter, whereas many U.S. systems have their annual peaks in the summer because of air conditioning. Systems that differ in this way can effect economies of scale by exchanging energy on a seasonal basis.

SERVICE AREA: The area within which a utility is required, or has the right, to serve consumers.

SINKS: Large areas of vegetation or ocean which absorb compounds such as carbon dioxide.

SMOG: Air pollution, usually a light brown haze, containing ground-level ozone, nitrogen oxides and other compounds.

SO_2: See Sulphur Dioxide.

SOCIAL BENEFITS: Benefits, whether tangible or intangible, resulting from a project. Social benefits are distinguishable from private benefits in that they include all the benefits of a project, whether or not they accrue to project sponsors.

SOCIAL COSTS: Costs or damages, whether tangible or intangible, which a project causes to be imposed. Social costs are distinguishable from private costs in that they include all the costs of a project incurred by all citizens rather than only those incurred by the project sponsors.

SORBENT: An additive used to enhance sulphur dioxide removal, e.g., limestone.

SPATIAL RESOLUTION: The reporting of emission data by geographic locations.

SPECIATION: The determination and reporting of specific elements or compounds that constitute pollutants such as: Particulates, Nitrogen Oxides and Volatile Organic Compounds.

STAKEHOLDERS: Interested and affected parties, including representatives of the public, industry and government.

STRATOSPHERE: A layer above the earth's atmosphere, between 10 to 50 km (six to 30 miles).

SULPHIDE: Compounds containing sulphur and some other element.

SULPHUR DIOXIDE: A heavy, suffocating gas with the chemical formula SO_2. Sulphur dioxide is created by both natural and anthropogenic activities. Anthropogenic sources include fossil fuel combustion and industrial activities. High levels of sulfur dioxide and suspended particulate matter (SPM) may cause respiratory problems among adults and children and may also result in lower respiratory tract illness.

SUSPENDED PARTICULATE MATTER (SPM): Levels of SPM rise both from human and natural activities including combustion of wood and fossil fuels, industrial activities, and dust raised by vehicular traffic or wind. High SPM levels may aggravate respiratory illnesses.

SUSTAINABLE DEVELOPMENT: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

TARGET LOADING: The maximum level of atmospheric deposition, based on dose-response and socio-economic analysis, that affords long-term protection from adverse ecological consequences.

TERAWATT HOURS (TW.h): One billion kilowatt-hours.

THERMAL GENERATING STATION: An electric generating station where the prime movers are driven by gases or steam produced by burning fuels such as coal, oil, gas, wood or refuse.

TON: Also known as a short ton, it contains 2,000 pounds. One ton equals 0.9072 tonne.

TONNE: A metric ton, or tonne, contains 1000 kilograms, or 2,204.623 pounds. One tonne equals 1.1023 tons.

TORONTO CONFERENCE: The World Conference - Changing Atmosphere: Implications for Global Security was held June 27 to 30, 1988 in Toronto.

TOXIC: Having or tending to have a harmful effect on the environment or man.

TRANSMISSION LINE: A line used for the transmission of electric power at high voltage. Transmission lines may be constructed overhead, underwater or underground.

TRANSMISSION SYSTEM: Lines, transformers, switches, etc. used to transport electricity in bulk from sources of supply to other principal parts of the system.

TROPICAL RAIN FOREST: Huge tracts of forest acting as "sinks" for carbon dioxide. Destruction has a dual effect: burning generates carbon dioxide; killing the trees eliminates another means of absorbing carbon dioxide.

TROPOSPHERE: The lower part of the earth's atmosphere, up to about 10 km, in which the temperature decreases with height.

TURBINE (HYDRAULIC): A rotary type of prime mover in which mechanical energy is produced by the force of water, steam or gas directed against blades fastened to a rotating shaft.

UN: United Nations.

UNCED: United Nations Conference on Environment and Development (Rio de Janeiro, Brazil, June 1992). Dubbed the "Earth Summit." Its objective is to have the heads of state examine ways of achieving sustainable development.

UNECE: United Nations Economic Commission for Europe (also ECE). Established through the UN in 1947, the ECE seeks to generate and improve economic relations among UN members and other countries of the world, and to strengthen inter-governmental cooperation in areas including the environment.

UNEP: United Nations Environment Program. The UN Environment Program, established in 1986, is governed by an international council. The UNEP seeks to promote international cooperation in the environmental field, provide general policy guidance to the UN on environmental issues and review implementation of UN environmental initiatives.

VOLATILE ORGANIC COMPOUNDS (VOCs): Hydrocarbon chemicals that evaporate easily and play a role in the creation of ground-level ozone.

WET DEPOSITION: A process of precipitation whereby acidic chemicals, including dilute sulphuric and nitric acids and sulphates, are deposited in rain, snow, etc.

WHO: World Health Organization. The WHO was established through the UN in 1948 and its organizational objective is the attainment by all peoples of the highest possible level of health.

WMO: World Meteorological Organization. The WMO was formed through the UN in 1950, as a successor to the International Meteorological Organization (established in 1873). The WMO was created to facilitate international cooperation in the establishment of networks of stations and centres to provide meteorological services, and to further the application of meteorology to human activity.

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PART II

REALIZING THE BENEFITS OF COMMUNITY INTEGRATED ENERGY SYSTEMS

PART II

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Part II

REALIZING THE BENEFITS OF COMMUNITY INTEGRATED ENERGY SYSTEMS

II.1 Introduction

The contemporary success of European district energy technology and integrated resource planning (IRP) has led to some limited adoption of European district energy planning methods and technology in both the U.S. and Canada. While European methods may not be directly transferrable to Canada because of differences in heating and cooling loads and in patterns of urban development, the potential benefits of community integrated energy systems (CIES) to Canadian communities are great and require concerted action to ensure the requisite benefits.

To better appreciate the benefits of CIES to Canadian urban communities and how to implement CIES on a broader scale in Canada, district energy development in several European countries is profiled here. This is followed by an overview of district energy in Canada--Charlottetown, Prince Edward Island; Toronto, Ontario and Edmonton, Alberta.

The purpose of this section is to briefly describe the experiences of several European jurisdictions with district energy, to outline its importance in reducing emissions in these countries and to discuss how CIES have been supported.

The reasons for the development of district energy in Europe differ among countries. Nevertheless, the common driving force has been the desire to produce a commodity--heat--with or without power, that is cost-competitive with alternative heat production methods.

Government encouragement in the form of mandatory connection policies and, in some cases, very significant financial assistance has led to the development of district energy networks at both the municipal and regional levels. The reasons for government support have, in some instances, gone beyond the objectives of greater fuel efficiency and use of indigenous resources to the achievement of security of energy supply. During the decades after WWII, greater concern with the environment resulted in increased interest in CIES. The oil crises of 1973-74 and 1979-80 provided further need for greater energy efficiency and off-oil substitution programs that again favored the development of CIES.[1]

The first CHP plants in Europe were established in the 1920s in larger towns and cities. In those days, electric power stations were located in the center of town and an obvious way to improve efficiency and reduce fossil fuel imports was to use waste heat from electric power stations for heating nearby buildings and industries.

Over the past 25 years, most northern European countries have extensively developed centralized heat production and combined the generation of heat and electricity (termed combined heat and power or CHP). Denmark, Finland, Sweden, the former republics of the USSR and Germany have extensive district heating networks.

Tables II.1 and II.2 show the relative importance of district energy, CHP's share of the total heat market, and the most important fuels used in district energy, in Denmark, Sweden and Finland.

II.2 Environmental Benefits and Taxes

The Northern European countries are still very much concerned about the environmental impact of energy use. Denmark was the first country to use high fuel taxes to prompt greater fuel savings, as early as 1985. Sweden followed a few years later and now the European Economic Community (EEC) is seriously assessing the possibility of broad-based fuel taxes to reduce environmental impacts.

Table II.3, summarizes energy prices and total environmental fuel taxes in Scandinavia.

General Situation in Europe

The energy discussion in Europe today centers on two main subjects:

- to renew the energy supply in Eastern Europe; and
- to improve energy efficiency in Western Europe, mainly by subsidies and taxes.

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[1] Monenco Consultants Limited, DHM Energy Consults Ltd., K-Konsult, and Cogeneration Associates Limited, *The Realistic Potential for District Heating in Canada, Volume I*, April 1985, p. 1-2.

TABLE II.1

BASIC DH AND CHP INFORMATION (1989)

Country		Denmark	Sweden	Finland
DH Share of Heat Supply	%	44	34	43
Number of DH Undertakings	-	365	145	132
Number of CHP Plants	-	35	29	58
Pipe Length	km	16,900	7,642	6,205
DH-production Including Industry	TJ	82,900	128,500	79,710
Share of Fuels of DH				
Coal	%	62	23	47
Natural Gas	%	14	11	18
Oil	%	4	4	13
Peat	%	0	5	18
Refuse	%	10	10	1
Other Sources	%	10	47	3
Share of Industrial DH Consumption	%	0	0	9
CHP Share of DH Production	%	58	14	68

SOURCE: B. Hojlund Rasmussen Consulting Engineers and Planners A/S, *Review of European Tariff and Regulatory Experience with the Sale of Heat and Electricity from Cogeneration Facilities*, Progress Report, Final Draft, for the Canadian Electrical Association, Prince Edward Island Energy Corporation, August 1991, p. 3.

TABLE II.2

ELECTRIC PRODUCTION BY TYPES OF ENERGY

Country	Denmark		Sweden		Finland		Norway	
	TW.h	%	TW.h	%	TW.h	%	TW.h	%
Conventional, CHP	11.5	37.5	1.7	1.2	8.6	13.8	0.0	0.0
Industry, CHP	0.0	0.0	3.4	2.4	7.7	12.3	0.0	0.0
Conventional, Condense	12.0	39.1	3.3	2.3	6.5	10.4	0.5	0.4
Nuclear Power	0.0	0.0	62.3	44.4	18.1	29.0	0.0	0.0
Hydro Electric Power	0.0	0.0	71.5	51.0	10.8	17.3	118.8	99.6
Wind Power	0.07	0.2	0.01	0.0	-	0.0	-	-
Net Import	7.1	23.1	-1.8	-1.3	10.8	17.2	-	-
Total	30.7	100.0	140.4	100.0	62.5	100.0	119.1	100.0

SOURCE: B. Hojlund Rasmussen Consulting Engineers and Planners A/S, *Review of European Tariff and Regulatory Experience with the Sale of Heat and Electricity from Cogeneration Facilities*, Progress Report, Final Draft, for the Canadian Electrical Association, Prince Edward Island Energy Corporation, August 1991, p. 4.

TABLE II.3

FUEL PRICES AND TAXES IN NORTHERN EUROPE, 1991 ($Cdn/GJ)

Country	Denmark	Sweden	Finland	Norway
Fuel Price				
Oil 0.2% S	7.4	9.2	9.3	10.0
Fuel Oil 0.7% S	4.8	5.6	6.1	8.1
Coal 1% S	2.0	2.3	2.0	-
Natural Gas	4.8-7.4	-	4.6	-
Peat	-	6.1	3.5	-
Wood Chip	6.6	6.1	7.4	6.1
Straw	5.4	-	-	-
Total Fuel Tax				
Oil 0.2% S	8.3	6.7	0.2	3.4
Fuel Oil 0.7% S	8.3	7.0	0.2	3.9
Coal 1% S	6.3	7.9	0.2	-
Natural Gas	(8.0)	3.3	0.1	0.3
Peat	-	3.0	0.2	0.0
Wood Chip	0	0.0	0.0	0.0
Straw	0	0.0	0.0	0.0

SOURCE: B. Hojlund Rasmussen Consulting Engineers and Planners A/S, *Review of European Tariff and Regulatory Experience with the Sale of Heat and Electricity from Cogeneration Facilities*, Progress Report, Final Draft, for the Canadian Electrical Association, Prince Edward Island Energy Corporation, August 1991, p. 6.

The second subject is receiving considerable attention by the European Economic Community. Large programs for developing and testing new energy technologies have been running for years and a general subsidy for a test project of up to 50 percent is not unusual.

In 1989, the EEC joined the Toronto conference, The Changing Atmosphere, in recommending reductions in CO_2 emissions:

- stabilizing before the year 2000;
- reduction by 20 percent before the year 2005; and
- reduction by 50 percent in the long term.

However, the EEC countries are divided into two groups on the issue of environmental fuel taxes--the highly developed, northern European countries that are interested in and can afford a fuel tax, and the poorer parts of Europe that cannot afford such a tax at this time. The North-South conflict in the EEC will likely be solved through provision of subsidies to the developing regions of the EEC. All Scandinavian countries are expected to be members of the EEC before the year 2000.

While the tax levels to be adopted in the EEC have not yet been decided, it will probably be according to the following:

- a small tax the first year, growing gradually to a high final tax level around the year 2000; and

- tax is to be paid by all consumers, including industries.[2]

II.3 Denmark

II.3.1 Overview

Denmark was the first European nation to use district heating and has used CHP technology for nearly sixty years. Denmark has about 350 district energy companies with about 600 district heating stations and substations.

Four inter-municipal transmission systems whose spheres of activity include planning, financing and operation of transmission networks for district energy transport hot water and sell it to the partner municipalities involved. Further transportation of the heat from the receiver points in the municipalities (heat exchanger stations) to the individual consumer is an area that is managed by the connected partners themselves.

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[2] B. Hojlund Rasmussen Consulting Engineers and Planners A/S, *Review of European Tariff and Regulatory Experience with the Sale of Heat and Electricity from Cogeneration Facilities*, Progress Report, Final Draft, for the Canadian Electrical Association, Prince Edward Island Energy Corporation, August 1991, p. 113.

The four transmission companies are:

- Aarhus Kommunale Vaerker (AKV)
- Trekantomraadets Varmetransmissionsselskab I/S (TVIS)
- Vestegnens Kraftvarmeselskab I/S (VEKS)
- Centralkommunernes Transmissionsselskab I/S (CTR)

The financing of the four transmission networks is primarily undertaken with the aid of foreign mixed-loans, raised from the European Investment Bank.[3]

Almost half the total space heating demands of the country are supplied by district energy plants, and of this about half is supplied by CHP, mostly from large- and medium-sized power stations. Many small district energy systems have been tied together to form large, integrated community energy grids. In one instance, a large integrated system of many small district heating plants is provided with heat from a 700 MW electric power station designed for up to 100 percent cogeneration. The town most remote from the power station is about 50 km (30 miles) from the station, measured along the transmission line.[4]

Denmark has a very long district energy tradition based on combined heat and power. The first power plants were situated in Denmark's largest cities and at an early stage, surplus heat from electric power plants was used for heating houses. In towns with more than 50 000 inhabitants, heat supply came from nearby power plants, and in smaller towns the heat supply came primarily from cheap fuel oil and municipal energy-from-waste CIES plants. With a few exceptions, all CIES were designed as hot water systems below 120°C.

In Denmark, about 40 percent of all houses have a district heating connection that is regarded as a most ordinary installation, just as any other utility connection such as water, electricity, or gas.

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[3] Metropolitan Copenhagen Heating Transmission Company, *Annual Report*, 1991, p. 2.8.

Cogeneration of electricity and heat was introduced in the 1920s and has developed with the extension of the electricity supply. The first units used diesel generators, but later, as larger units became necessary, steam turbines were introduced.[5]

Up to 1973, the year of the first oil crisis, about 95 percent of Denmark's power production was based on oil and only 5 percent sourced from coal. Today, the situation has been reversed. Coal now meets 95 percent of the power industry's fuel requirements, while oil and natural gas supply the remainder. This restructuring has been accompanied by greater use of surplus heat from CHP plants, and waste heat from waste-to-energy incineration plants and industry.

A considerable expansion of heat transmission and distribution networks took place when power stations and CHP plants were carrying out their major off-oil fuel switch. One of the more important developments in the heating picture has been the growth of district heating systems serving almost an entire city or region.[6]

In the Copenhagen area, a large interconnected CIES network supplies a significant share of the heat demand in eighteen municipalities. In this system, the power companies own the CHP plants and sell heat "at the gate".

The gross energy consumption for heating purposes has decreased almost 45 percent since 1979. This decline is credited to use of surplus heat, introduction of more efficient energy technologies and changes in consumer behavior. In addition, the net heat demand distributed according to heating systems shows an important shift from individual oil burners to collective systems, especially district heating. In 1990, district energy covered 44 percent of Denmark's accumulated net heat requirements compared to 25 percent in 1972. Over the same period, natural gas rose from virtually nothing to supply about 10 percent of the market in 1990.[7]

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[4] Lund-Jensen, G. Vanglund, "Cogeneration and District Heating," *Proceedings of the Euroforum - New Energies Congress, Volume 1, Saarbrucken, Germany, October 24-28, 1988.*

[5] Knut Berge, ELKRAFT Power Company, "Rational Use of Energy in Denmark," 13th Annual IAEE International Conference, Copenhagen, Denmark, June 19-21, 1990, p. 2.

[6] Ibid.

[7] Metropolitan Copenhagen Heating Transmission Company, *Annual Report*, 1991, p. 2.4.

Denmark has many district energy undertakings:

- twenty large utilities (mostly public utilities) use CHP from large coal-fuelled CHP plants to deliver 58 percent of Denmark's district energy production (see Table II.1).
- sixteen smaller public utilities using other energy sources deliver 16 percent of Denmark's district energy production.
- 299 private, consumer-owned utilities deliver the last third of the district energy production.[8]

In the greater capital area of Copenhagen two large transmission companies comprised of fifteen municipalities have joined in forming what is expected to be one of the largest CHP/district energy systems in the western world. The transmission system will have a length of 150 km and supply 325 000 households with 25 000 TJ/year.[9]

For Denmark as a whole, investments over the 1985-2000 period are estimated at $3.5 billion (US) in plants, transmission and distribution systems. These investments are expected to have a significant impact on the national economy due to the (1) higher efficiency due to otherwise wasted fuel in the cooling water; (2) use of low priced energy; and (3) reduced impact on the environment. It is estimated that the ongoing CHP development program will provide a benefit to the national economy that allows a payback in investment of twelve to fifteen years.[10]

II.3.2 Energy-From-Waste

Energy-from-waste is used primarily for space heating where the plants interconnect with local district energy systems, although some plants also produce electricity as well. In the early 1930s, the first continuously working refuse incinerator in the world went into operation in a northern suburb of Copenhagen. The energy generated from this plant is used to produce electricity and district heating. Today, more than 46 energy-from-waste plants are in operation producing heat for approximately 7 percent of the total Danish space heating requirements.[11]

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[8] B. Hojlund Rasmussen Consulting Engineers and Planners A/S, *Review of European Tariff and Regulatory Experience with the Sale of Heat and Electricity from Cogeneration Facilities*, Progress Report, Final Draft, for the Canadian Electrical Association, Prince Edward Island Energy Corporation, August 1991.

[9] Knudsen and Ricken, *Development of Danish Combined Heat and Power Systems*, World Energy Conference, September 1989.

[10] Ibid.

According to Denmark's energy and environmental policies municipal waste must be handled according to the following priorities:

(1) Reuse
(2) Recycling
(3) Municipal waste CHP plant
(4) Municipal waste hot water plant
(5) Landfill

Today most garbage is burned in municipal waste-to-energy plants with the surplus heat used as base load in the CIES network. The first municipal waste-to-energy plants are being rebuilt for CHP production and more will be built in the coming years with advanced flue gas cleaning equipment. In Denmark, heat production from municipal waste-to-energy plants covers 20 percent of the total heat production. All the plants are owned by groups of municipalities, some of them supplied by the district energy system and getting their own municipal waste heat back.[12]

II.3.3 The National Energy Strategy

Since 1973, the Danish energy sector has undergone dramatic developments. At the outset of the 1970s, 95 percent of the total energy consumption for heating purposes was based on imported oil as the only source of supply. Today, dependence on imported oil has dropped to less than 45 percent, and at the same time energy consumption for heating purposes has fallen by 30 percent compared with pre-oil-crises levels.

These remarkable results have to a large degree been obtained due to a very deliberate heating program involving a heavy expansion of the country's community integrated energy systems.[13]

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[11] Otto Jensen, Volund Miljoten\knik A/S, "Energy-From-Waste Facilities," *Proceedings of the Euroforum - New Energies Congress, Volume 1, Saarbrucken, Germany, October 24-28, 1988.*

[12] B. Hojlund Rasmussen Consulting Engineers and Planners A/S, *Review of European Tariff and Regulatory Experience with the Sale of Heat and Electricity from Cogeneration Facilities*, Progress Report, Final Draft, for the Canadian Electrical Association, Prince Edward Island Energy Corporation, August 1991.

[13] Metropolitan Copenhagen Heating Transmission Company, *Annual Report*, 1991, p. 2.1.

II.3.4 Environmental Benefits

Factors other than the actual price of heat play a vital role when comparing the competitiveness of CIES with that of individual, on-site heating supply options. Among these, concern for environmental protection and emissions reduction are paramount in Denmark's current and prospective energy planning.[14] Denmark has been one of the pioneers of international actions to reduce the environmental impacts from energy use.

According to Denmark's energy-environment blueprint for the future--(Energy 2000)--carbon dioxide emissions are forecast to decline by 20 percent over the next fifteen years. Within the same period, sulphur dioxide emissions are expected to drop some 60 percent and nitrogen oxide by approximately 50 percent.

Present Energy 2000 target values are

For SO_2: Compared to the 1980 level, the emissions will be reduced by 30 percent by 1993, and 60 percent by 2005.

For NO_x: Compared to the 1980 level, the emissions will be reduced by 50 percent by 2005.

For CO_2: The present levels should be reduced by 20 percent in 2005 and by 50 percent in 2030.

Greater use of CHP offers a significant contribution to the projected emissions reductions, as CHP offers a 30 percent reduction in emissions compared to the separate production of heat and electricity.

As Denmark's aggressive CIES development to date testifies, it is easier to control emissions from a few large plants than it is to control emissions from thousands of boilers spread across a city. Also, as less energy is consumed through CHP and use of waste heat is made in a CIES network, emissions per delivered unit of heat are significantly reduced.[15]

Moreover, increasing public demands to find environmentally acceptable ways of disposing of waste products such as garbage, chemicals, straw, etc. has given CIES a new and important dimension, as energy from almost any combustible material can be used to cost-effectively produce heat and electric power.

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[14] Ibid., p. 4.5.
[15] Ibid.

In addition, Denmark's government seems prepared to take more decisive steps to ensure that the objectives of Energy 2000 are met and that further CIES development takes place. For example, a recent statute imposes connection to CIES networks of existing buildings surpassing a certain size--an unusual step in Denmark's history of heat supply.

The benefit to the environment of CIES is evident in past and expected performance. It has been estimated that Denmark's energy policy, which prompts expansion of CHP and CIES, will account for about one-third of the total reductions in emissions from Denmark's energy sector over the 1980-2000 period. CHP development has already resulted in important regional emissions impacts due to the change in the geographical distribution of pollution sources. At the local level, the "respiratory pollution" from scattered sources has been and will be considerably reduced.[16]

Some local environmental problems are also solved by using waste products for energy purposes, such as household wastes which are collected and the non-reusable portion burned in incineration plants connected to CIES. Other waste products used for CHP include animal manure which is transformed to biogas, and excess straw from farming. Presently, 49 district heating stations are straw fired. These plants will, wherever possible, be converted to CHP during the next decade.[17]

II.3.5 Energy Planning and Legislation

In Denmark, CIES is promoted by legislation--primarily the Heat Supply Act.

The Heat Supply Act passed by the Danish Parliament in 1979 contained provisions for the initiation of nation-wide heat supply planning. The purpose of the Act was to promote the most economic use of energy for heating buildings and supplying them with hot water and to reduce the country's dependence on oil. To achieve this, a radical restructuring of the heat supply system was initiated. This included a large-scale conversion from individual use of oil to community integrated energy systems based on natural gas and district heating. In parallel with the implementation of this new form of planning, Danish municipalities and counties were directed to start general heat planning in 1982-1983.[18]

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[16] Knudsen and Ricken, *Development of Danish Combined Heat and Power Systems*, September 1989.

[17] Knut Berge, ELKRAFT Power Company, "Rational Use of Energy in Denmark," 13th Annual IAEE International Conference, Copenhagen, Denmark, June 19-21, 1990.

The Heat Supply Act requires that local authorities arrange for mapping the existing heat requirement, the heating methods used, and the quantities of energy, including surplus heat, that are used or can be used in the heat supply, and produce an estimate of future heat requirements and the future possibilities for heat supply in the municipalities.[19] This mapping is carried out partly in co-operation with companies supplying piped energy. Each municipal council then prepares a proposal for the organization of the municipality's heat supply.

The development and extension of district heating played a crucial part in the general heat planning from the very beginning. This is due to the robustness and flexibility of the district heating supply system that is able to use a multiplicity of fuels. In addition, the predominant use of low temperature hot water as a medium (i.e., below 120°C) in Danish district heating networks is very favourable as regards the application of waste heat from combined heat and power plants, waste-to-energy incineration and industries.

Adjustments to the Heat Supply Act

In 1985, the Danish Government decided that the application of Danish resources was to have priority in the country's ongoing heat planning. This meant that district heating companies primarily had to use natural gas, surplus heat from electric power stations, straw, waste and wood. At the same time, this policy was reinforced by an increase in energy taxes on oil and coal to prevent falling fuel prices from affecting prices to the final customer.

As regards fuel use within the heating sector, the following changes have been accomplished by the Act:

- The current share of oil in gross energy consumption is today 44 percent, compared with 95 percent in 1972.

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[18] Metropolitan Copenhagen Heating Transmission Company, *Annual Report*, 1991.

[19] Ibid., p. 2.3.

- The share of coal has increased from 6 percent in 1972 to 40 percent in 1990.
- Improved utilization of surplus heat from power stations and industry--CHP now covers 58 percent of the total consumption of district heating in Denmark.
- A significant Danish production of renewable energy based on new technologies is well under way and is today providing some 6 percent of total energy requirements.[20]
- The Act defines district heating companies as "collective utility companies", that are to be self-supporting. The heat price must be determined by the costs, and the company must not show a profit.[21]
- By the use of municipal heat planning, areas are reserved for district energy thereby ensuring that the district energy company has a monopoly over heat supply and need not worry about competition from other suppliers of piped energy.
- Oil prices--including government tax--are kept at 1985 levels, thereby promoting a long-term and stable extension of community integrated energy systems.
- The Heat Supply Act authorizes municipal authorities to demand that all new buildings are connected to the district energy system as district heating in existing buildings will be a success only if a sufficient number of consumers are connected to the system. Denmark has not found this to be a problem but, if necessary, municipalities are able to enforce connection under the provisions of the Heat Supply Act.

II.3.6 Future Energy Planning

While security of supply and the most efficient and economic use of energy have been major reasons for introducing and extending community integrated energy systems, environmental protection has come to be the major reason for CIES development.

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[20] Ibid., p. 2.4.

[21] Anders Dyrelund and B. Hojlund Rasmussen, Consulting Engineers and Planners A/S, "Energy Management in District Heating Systems," *Integrated Energy Markets Conference Proceedings*, IAEE 13th International Conference, Copenhagen, Denmark, June 19-21, 1990, p. 7.

In 1990, the Danish Ministry of Energy published a new energy plan, ENERGY 2000 and a few months later this energy plan was followed by a new Heat Supply Act 1990, where concern for environmental protection has been explicitly defined.

The new Danish energy plan pays special attention to efficiency in the supply system and specifies various strategies to:

- increase cogeneration - especially local cogeneration,
- increase the number of households connected to CIES,
- increase efficiency in electricity production, and
- introduce cleaner technologies, and use low emission fuels.

The purpose of this Act is, from an economic and environmental point of view, to promote the best possible use of energy for heat and hot water supply to buildings and to reduce the dependence on oil in the energy supply.

The Act expressly states that "the adoption of heat supply has to be carried so as to promote combined production of heat and power as much as possible" - a statement that is referring to a very ambitious program for a continued expansion of combined heat and power, including small-scale, back-pressure power stations based on natural gas and waste, straw, wood and wood-chips.[22]

According to recent estimates, about 80 to 90 percent of total heat consumption will be based on community integrated energy systems in the year 2002. Further substitution of gas for oil in individual oil burners and fuel oil and coal in existing district energy plants with other indigenous sources, will support the objectives of the previous energy plan.

The result of Denmark's energy policies on CIES development is shown in Table II.4--district energy jumps from 38 percent to 61 percent of total space and water heating requirements between 1987 and 2010. In fact, a significant part of the projected 1987-2010 development has already taken place in the last three years and the remainder is expected to be in place before the year 2000.

According to the Heat Supply Act, district energy utilities are only allowed to factor necessary costs, including a reasonably low

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[22] Metropolitan Copenhagen Heating Transmission Company, *Annual Report*, 1991, p. 2.4.

TABLE II.4

DENMARK'S SHARE OF SUPPLY AND ENERGY SOURCES FOR SPACE HEATING AND DOMESTIC HOT WATER

(percent)

Share of Supply		1987	2010
Large CHP steam	- Coal	5	0
	- Natural Gas	0	4
Large CHP Hot Water	- Coal	13	18
	- Natural Gas	2	7
Smaller CHP Hot Water	- Natural Gas		12
	- Waste		3
	- Biomass		6
Total CHP		20	50
DH Boilers	- Natural Gas	5	2
	- Waste	4	3
	- Biomass	1	1
	- Oil	5	4
	- Coal	3	1
Total DH Boilers		18	11
Total DH		38	61
Small Boilers	- Natural Gas	6	15
	- Oil	43	11
	- Renew.	8	8
Electric Heating		5	5

SOURCE: B. Hojlund Rasmussen Consulting Engineers and Planners A/S, *Review of European Tariff and Regulatory Experience with the Sale of Heat and Electricity from Cogeneration Facilities*, Progress Report, Final Draft, for the Canadian Electrical Association, Prince Edward Island Energy Corporation, August 1991, p. 9.

rent of the invested capital, into the heat price. The heat price has to be announced to the Heat Price Commission which approves both the tariff and the price level. As such, the district energy business cannot be profitable for an investor and district energy companies are therefore in reality owned by the consumers. The companies are either managed by politicians and municipal administrations (public utility) or by a board picked by the consumers. All the private district energy companies are co-operatives, owned by the heat consumers.[23]

Under the Heat Supply Act, the individual municipality is responsible for the local heat planning and for the accomplishment of the plans under the guidance of the Danish Energy Agency. In general, the connection to the public heat supply system can be made mandatory, as well as utilization of certain energy options for heating can be forbidden. For example, electrical heating cannot be adopted for new housing.

Under the new Heat Supply Act, efforts will be made to convert all heating installations (except industrial) with a heat output above 1 MW to CHP. For units with an electric power output of less than 25 MW, coal is not allowed as a fuel source. According to Danish energy policy, existing coal-based installations for heat supply should only be converted to CHP stations based on natural gas if available, and otherwise on local energy resources.

One of the main advantages of the Heat Supply Act is to ensure good economy in the energy sector by avoiding double investments by building distribution network for district heating as well as natural gas in the same supply area. The Act describes a planning procedure, according to which the electric utilities, the district heating, and the natural gas supply companies have to cooperate with the energy authorities at the local, regional and national level concerning heat plans for specified areas. Every urban district in the country assembles the relevant stake-holders to formulate a plan describing the best technical-economic solution for heat supply based on local conditions.

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[23] B. Hojlund Rasmussen Consulting Engineers and Planners A/S, *Review of European Tariff and Regulatory Experience with the Sale of Heat and Electricity from Cogeneration Facilities*, Progress Report, Final Draft, for the Canadian Electrical Association, Prince Edward Island Energy Corporation, August 1991.

II.3.7 Levers Promoting District Energy and CHP[24]

Denmark's most important levers for promoting district energy and CHP have been:

- New, Large Power Plants

  According to the Electricity Supply Act, new large power plants have to be approved by the Energy Agency.

  The main conditions for this approval are:

  - the plant must be a CHP plant; and
  - the plant must be situated with regard to the largest CHP potential.

  No new, large coal-fired plants will be accepted before all efforts have been attempted to develop smaller CHP plants, fueled by natural gas or renewable sources such as municipal waste water, straw, wood chips, etc.

- Monopoly

  Municipal heat plans must be undertaken and must be approved by the Ministry of Energy. These plans specify the location of district energy networks, natural gas networks and individual supply, according to what is most beneficial for Denmark. This means the district energy company will meet no competition from the natural gas supplier in the supply areas. Also, electric heating is prohibited in new buildings.

- No Profit

  The district energy companies are not allowed to profit. In the long term, all benefits must accrue as a reduction in the heat price. Tariffs and prices have to be reported to the Gas and Heat Price Committee, that can intervene and declare the price illegal, if the basis of the tariff or the price is unreasonable.

- CHP Tariff Regulations

  According to the Electricity Supply Act, all power companies are in principle also non-profit companies, as only necessary cost may be incorporated in the electricity price.

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[24] Ibid., p. 17.

Also, electricity supply undertakings, that deliver heat and electricity in combined production, shall distribute costs according to reasonable and business-economic principles. Prices are reported to the Price Committee, that has the authority to demand the price or conditions be changed if they are unreasonable.

- Hook-up of New Customers

The municipality has several levers to enforce the hook up to the CIES network, whether it is public or consumer owned.

For new buildings, the municipality can specify the supply according to both the Heat Supply Act and the General Municipal Planning Act. A CIES network is regarded as a natural and important part of the infrastructure in new housing development areas, just as sewage, water supply and other service lines.

Where possible, old buildings supplied by individual boilers above 0.25 MW are to be connected to the CIES (or natural gas) network within a time limit of one year.

For old buildings supplied by individual boilers smaller than 0.25 MW, the municipality has the authority to decide whether to force them to hook up to the CIES within a time limit of nine years.

Exemption will be granted if it is unreasonably expensive to supply the old heating system by hot water district energy--e.g., if no hot water or air heating system is installed.

- Heating Installation in Buildings

Until now, Denmark has been completely without legislation concerning design temperatures of heating systems in buildings. In several cases, this has resulted in higher district energy temperatures and more expensive supply than necessary. But, in the new building code (1993), a low temperature design criteria will be specified, probably at the level of a supply temperature of 70°C and return temperature of 35°C in the design case (-12°C outside).

- More CHP Plants

By specifications from the Ministry of Energy and the municipalities, almost all district energy utilities now using heat-only boilers are, according to the

Heat Supply Act, being forced to turn to CHP, either by producing CHP themselves or by buying heat from a utility-owned CHP plant.

After negotiations with the Ministry of Energy, the power utilities have "agreed" to spend money on a CHP test program. Also, the power utilities have agreed to assume the risk of small CHP projects, if the local district energy utility does not want to.

- Subsidies

  Both the EEC and the Danish Energy Agency run large subsidy programs for developing and testing new energy technologies. Special development projects can be granted close to 100 percent of the cost. Test projects that are closer to a commercial level may be granted up to 50 percent of the investments.

- Taxes

  The Danish fuel tax is very high compared to many other countries. This fuel tax acts as an indirect subsidy to promote CHP projects, district energy projects and other fuel energy saving projects.[25]

  According to the new Carbon Tax Act, the electricity carbon tax will be refunded for all electricity produced by municipal waste CHP plants.

II.3.8 Financial Aspects

Community integrated energy systems involve considerable capital-intensive investment. As most consumers take a short-term view when choosing heat supply, the district heating price and connection charges have to be competitive with other heat supply options from the very start. District energy companies therefore have to accept that there will be a relatively long period of time before the initial investment has been paid back and positive net revenues start to accrue.

Planning periods of fifteen to twenty years are common and the price of heat is set as an average for the entire period. This means that initial low revenues are financed by means of loans, thereby transforming the long-term economic advantage for the district heating companies into an immediate benefit for the consumer. However, as district energy systems have a lifetime of about fifty years (much longer than the pay-back period for the investment), this means that the economic and financial situation improves considerably after the initial build-up phase.[26]

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[25] Ibid.

Generally, for the first ten to fifteen years the heat consumers pay only the marginal costs, thus indemnifying the electric consumers. After this period, the benefit of combined production compared with the best alternative heat supply option is shared, often on a fifty-fifty basis.

Long-term loans allow a levelling of the fixed costs over long periods of time. Financing of the major transmission systems have been arranged by long-term loans, mainly in foreign currency. The return on the loans has been arranged in a way that allows levelling the fixed costs over a planning period of 15 to 20 years. This enables the consumers to obtain an immediate advantage from the savings in fuels and constitutes an incentive toward voluntary use of the CHP/district energy systems.[27]

II.3.9 Tariffs

In Denmark, heat prices are based on actual costs and must be reported to the Gas and Heat Price Committee in order to be valid. Some important assumptions bear noting:

- For the first twelve years, heat consumers pay only the marginal costs for the heat from combined heat and power plants, thus indemnifying the electricity consumers.

  The reason for this approach is that, until the investments in the transportation system have been paid back, there is no real benefit to be shared. After the grace period, the benefit of combined production compared with the best alternative heat supply option is shared, often fifty-fifty.

- Incineration plants might be considered part of the refuse collection service, and thus heat consumers should pay only marginal costs related to the plant. However, this approach is not applied due to conflict of interest, either between the individual municipalities involved, or between the different utilities in the municipality. Payment is related to the energy price from combined heat and power plants, i.e., a substitution price.

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[26] Metropolitan Copenhagen Heating Transmission Company, *Annual Report*, 1991, p. 2.7.

[27] Knudsen and Ricken, *Development of Danish Combined Heat and Power Systems*, September 1989.

- Costs related to the transmission system are well defined. The question is how to allocate the expenses to the different distribution companies. Commonly a pooled-price is used so that the heat price ex-transmission system is the same for all the connected distribution companies.[28]

Large CHP plants built as extraction power plants serve primarily to produce electricity. The present practice in pricing the heat delivered from the extraction plants involves payments by the heat consumers of all extra costs related to the delivery of heat. Thus, the electricity consumers are not charged with any extra costs due to the supply of heat, but also they do not receive a share of the economic advantages of being connected to the combined production of heat and power--at least for a considerable time until the investments in plants, transmission pipes, pumping stations, and heat exchangers have been paid back.[29]

In the calculation of costs related to heat production, the following elements apply:

- all components of relevance to the heat production possibility, i.e., pumps, heat accumulators, tanks, instrumentation;
- all extra fuel for the heat production and similar operating costs, e.g., additives to the water sent out into the pipelines;
- reduction of the available capacity for electricity production;
- any inconveniences to the load dispatcher due to operating restrictions referable to the heat delivery; and
- a certain agreed part of administrative costs.

In the case of back pressure plants--normally built as small- or medium-sized plants--electric power production is considered to be a byproduct of heat production. Often a heat accumulator is used to reduce this tie between power and heat production. Depending on the capacity of the heat accumulator, it may be possible to use the plant intermittently at full load irrespective of the heat requirement. Thus, the power capacity of the plant can be fully used during morning and evening peak loads.

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[28] Metropolitan Copenhagen Heating Transmission Company, *Annual Report*, 1991.

[29] Knudsen and Ricken, *Development of Danish Combined Heat and Power Systems*, September 1989.

The typical tariff for CHP from a coal-fired extraction plant is based on the fact that the power companies would have to build the new coal-fuelled condensing plants anyway. The basic principle of the typical tariff implies a long-term share of the benefit between the power company and the district energy company. However, in the first twelve to fifteen years there is no benefit to the power company.

II.4 Sweden

Sweden first established district energy in 1948. Since then it has expanded rapidly and now comprises 34 percent of the space heating market--somewhat less than in Denmark and Finland (see Table II.1).

District energy has expanded sharply since 1965, when a total of 2.4 million square meters of space was heated by means of CIES systems. This figure rose to 9.8 million in 1975 and to 22.8 million in 1985.[30] Sweden's district energy system is based on a diversity of fuels and production methods. Fuel oil, coal, refuse, biomass and peat as well as heat pumps and electric boilers are used in Sweden's CIES networks. The latter are used during times of the year when cheap electricity is available on the Swedish power market.[31]

Swedish cities, like cities in other Scandinavian countries, have comparatively large powers including taxation rights. **In the energy field this means that the distribution of gas and electricity in almost every city is made by the municipality or by a company owned by the municipality.** Every city has the obligation to make an energy plan that originally started as a plan to diminish the dependance on oil.

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[30] The Swedish District Heating Association and the Swedish Trade Council, *District Heating, Clean Heat for Urban Areas*, Sweden: The Swedish District Heating Association and the Swedish Trade Council.

[31] Rolf Stalebrant, Swedish District Heating Association, "DH Coordination with Local Industries for Economic and Environmental Improvements," *IDHCA Proceedings 1991*.

II.4.1 Legislation Supporting District Energy

Three Parliamentary acts--The Municipal Energy Planning Act, The Act Governing Combustion Facilities for Solid Fuels and The Environmental Protection Act--have had a major influence on the allocation of resources for Sweden's CIES development.

II.4.1.1 Municipal Energy Planning Act

The latest amendment to the Act (1985) states that every municipality is to have a plan for the supply, distribution, and utilization of energy within the municipality and that the plan must be accepted by the municipal council.

Under the terms of this Act, Swedish municipalities are to promote energy conservation and work to secure a safe and adequate supply of energy. They are to investigate the advantages of cooperation with other municipalities, or with large industrial organizations. Each municipality is also responsible for preparing a plan to reduce its dependence on oil, and this plan is to be reviewed on a regular basis. The Act establishes that energy matters are assuming such importance that municipalities must establish an action program for energy policy. The task is eased appreciably if the municipality has a CIES, since CIES offers great flexibility in the choice of fuels.[32]

II.4.1.2 Act Governing Combustion for Solid Fuels

This Act requires that all new and permanent installations of district heating and other heating systems with an estimated consumption of 50 GW.h (170 million Btu) or more per year be designed to allow rapid conversion to burning any solid fuel available in Sweden.

II.4.1.3 Environmental Protection Act

Under the terms of the Act, combustion facilities must be designed so that the impact on the environment is limited. The Act specifies maximum allowable emissions of dust, acidic substances and heavy metals.

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[32] The Swedish District Heating Association and the Swedish Trade Council, *District Heating, Clean Heat for Urban Areas*, Sweden: The Swedish District Heating Association and the Swedish Trade Council.

II.4.2 Environment

In the early sixties, larger cities in Sweden were suffering from very high sulphur dioxide levels--the only evident solution was district energy. As well as environmental reasons for district energy development, there were also economic reasons. There has been great expansion of district energy and an associated dramatic improvement in environmental conditions over the last twenty years.[33]

Waste heat from industrial processes and heat from sewage water, transformed through heat pumps, are important means of district energy production today. Refuse incineration is also used in several municipalities.

District energy as a means of distribution makes it possible to choose the best production units and most competitive fuels. Environmental steps can consequently be taken at reasonable costs for the customers. The growth of district heating in Stockholm has resulted in a dramatic drop in the emission of harmful substances.

Because of its use of district energy, Sweden has been able to sharply reduce its dependence on oil. In more than half of the country's district energy municipalities, oil today accounts for only about 10 percent of the fuel used for district heating.

II.4.3 Financing Swedish CIES

Because district energy involves substantial investments, all factors that affect financing and rates must be closely scrutinized. The availability of capital is therefore a key factor in the cost-effectiveness and rate-setting of district energy.[34]

In Sweden, district energy systems are financed mainly through borrowing in the capital market and connection fees with customers. Initially, the district energy company will have limited operating revenues until a sizeable number of customers have been connected. Instalment loans and loans with long maturities are usually sought. While special district energy loans that meet these requirements are available in the Swedish market, they carry relatively high interest rates and government subsidies are not available.

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[33] World Energy Conference, "The Positive Effect of District Heating on the Environment," 14th Congress of the World Energy Conference, Montreal, Quebec, September 17-22, 1989, Session 2.3.6.

[34] The Swedish District Heating Association and the Swedish Trade Council, *District Heating, Clean Heat for Urban Areas*, Sweden: The Swedish District Heating Association and the Swedish Trade Council.

II.4.4 Operation of Swedish CIES

Swedish municipalities have traditionally been responsible for the distribution of electric power and water, sewage systems and the collection and disposal of refuse. Consequently, their assumption of responsibility for district energy was a natural outgrowth of this experience and expertise.

Most Swedish municipalities have a single energy supply authority operating through two divisions: a heat division that supplies district heating; and an electric power division. An administrative unit manages the divisions and provides staff services. In some municipalities, however, the district energy authority is an entirely independent agency.

Organizations responsible for district energy operations include municipal companies, municipal administrations and non-municipal operation(s).

II.4.4.1 Municipal Companies

More than half of the municipalities with district energy systems have a municipal energy company. The corporate form of organization is now generally chosen when a community is engaged in district energy. In other instances, a government-owned power company or one that is privately-owned, as well as an industrial company, may participate in the ownership. Two major advantages of the corporate form of organization are the strict financial accountability it imposes on the board of directors and president of the company, and the freedom of action it allows management. As a separate legal entity, the district energy company is not part of the municipal government. The company is entirely self supporting but, in contrast to companies owned by private investors, it is not permitted to operate on a "for profit" basis.[35]

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[35] Ibid.

II.4.4.2 Municipal Administrations

When the energy supply authority is part of the municipal administration, it generally retains a distinct position. It may for example, have a separate accounting system. In cases where the municipality manages the energy supply authority, separate companies are usually established to generate electric power and heat. But the distribution of power and district energy is handled directly by the municipality.

II.4.4.3 Non-Municipal District Heating Operations

In Sweden, there are many exceptions to the municipal models--notably cases where systems similar to district energy systems supply heat to residential areas containing up to 2000 apartments, or to a university or hospital. Such local systems have often marked the beginning of municipal CIES networks and in many cases have later been included in these systems. Similar approaches also occur in many other countries where fully or partly-owned companies may own and operate CIES networks.[36]

II.4.5 Tariffs

The heat price is defined by the tariffs and taxes of fuel and electricity. The municipal power company, which is a section of the public utilities, buys electricity from both the regional power company and the local CHP plant at exactly the same tariff. This means that the district energy company, which is another section of the public utilities, bears the whole risk and receives the whole benefit of the CHP plant.

Rate structures are designed to assure revenues adequate to guarantee continuity of operation and long-term growth. As is the case with other municipal operations, the rates are intended to cover costs, not yield a profit. Charges must be distributed fairly and reasonably. The rate structure must be readily understandable by the user and accurate cost data must be provided.

District energy rates must also be competitive with rates for alternative forms of heating available to customers. This requirement has had an important bearing on the expansion of Swedish district energy. A heating plant has high capital costs and low utilization of capacity in its initial period of operation. Normally an energy supply authority could expect to charge high rates during this period as a means of obtaining a reasonable return on its investment. But the Swedish District Heating Association and the tenant and landlord associations have jointly established maximum rates for district energy that may not exceed the costs the customer would have incurred by heating his building with oil.

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[36] Ibid.

II.4.6 Examples of Swedish CIES

II.4.6.1 Gothenburg

Gothenburg, Sweden's second largest city with a population of approximately 430 000, is a textbook example of Swedish CIES development. In the 1950s, to generate electric power more economically, city authorities converted an oil-fired condensing power station to a CHP plant, distributing the heat from the hot cooling water in a small, centrally-located district energy network. Later, a new CHP plant was constructed in another part of the city to serve a second district energy network. The expansion continued with the installation of hot-water boilers, and new customers were linked to the system. But the areas served continued to be "islands", isolated from each other.

The oil crises forced many municipalities to seek ways to reduce their dependence on oil and find less expensive heat sources. Gothenburg chose to use waste heat from a large refinery, under a contract offering substantial financial benefits to both the municipality and the refinery. In addition to reducing oil consumption sharply, the cooperative venture gave significant environmental benefits, as the waste heat used in the community CIES replaces heat that otherwise would have been supplied through combustion.

Waste heat has proved to be an inexpensive source of heat in Gothenburg's expanding CIES system and the city has continued to invest in waste heat projects. It has one of the world's largest heat pump plants for heat recovery from purified sewage water. The heat from the refinery and heat pump plant is transported to the CIES network via a 3.5 km tunnel under the Gota River.

As shown in Gothenburg, investments in systems that replace oil can be profitable. The project involving the refinery in Gothenburg used waste heat to replace heat provided by 50 000 tons of oil during the project's first years--the investment was recovered in less than two years through lower fuel costs. The payoff period for the heat pumps recycling heat from sewage water was less than three years.[37]

Gothenburg now has the most extensive district energy network in Sweden with about 350 km piping. The system has replaced many old, smoky furnaces and boilers and has considerably improved the air quality in the city.[38]

With the construction of a waste-to-energy plant in 1972, a new dimension was added. The new plant was connected with the existing district energy network, giving residents a reliable source of heat and solving the refuse problem. The plant currently incinerates about 260 000 tons of refuse per year from the Gothenburg region.

A positive environmental effect has been achieved by expansion of district energy in Gothenburg. From 1979 to 1990, the percentage of fuel oil in the heating system decreased from 90 percent of the total energy input to 7 percent. The fuel oil has been superseded by excess heat from solid waste combustion, from refineries, from sewage treatment plants and from the burning of coal and natural gas. Discharge of sulphur dioxide and nitrogen oxide from the plants from 1973 to 1990 has decreased by 90 percent and 40 percent, respectively.

In a normal year, district energy in Gothenburg is now based on a fuel mix in which refuse, industrial waste heat, heat pumps and coal and oil account for approximately 20 percent each. An estimated 80 percent of Gothenburg's heating requirements came from CIES in 1988.

In some district heating areas, a utility customer may also be a supplier. In Gothenburg, some customers deliver surplus heat to the network during certain periods of the year and purchase heat at other times. The city has special contracts of this type with a large industrial company, a technical university and a neighbouring municipality.

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[37] Ibid.

[38] World Energy Conference, "The Positive Effect of District Heating on the Environment," 14th Congress of the World Energy Conference, Montreal, Quebec, September 17-22, 1989, Session 2.3.6.

II.4.6.2 Malmo

The community of Malmo is situated at the Oresund, the strait between Denmark and Sweden, and has a population of about 250 000.

District energy was introduced in 1951. District energy was added as a valuable complement to improve the economics of a necessary electrical generating plant for standby and peak power demand.[39]

As a first step, a small hot water boiler plant was erected. From this, a CIES network was expanded towards an old power plant in the centre of the town, giving birth to the district heating system.

The development of the district system has created cleaner air. For example, district energy has reduced the number of chimney stacks in Malmo from 50 000 to some thousands.

The houses of Malmo are to some extent heated individually - with individual boilers, that are oil-fired or natural gas fired (5 percent). About 5 percent are heated electrically, but the most overwhelming part of the heat, about 90 percent, is supplied by the district energy system.[40]

For 1989, the district heating figures are (total delivery 2500 GW.h):

Coal	12 percent
Refuse incineration	22 percent
Natural gas	36 percent
Industrial waste	22 percent
Sewage heat pumps	6 percent
Oil	2 percent

For the city of Malmo, having its own facilities to produce electricity has meant:

- a safe back-up if something happened to the national electricity grid.
- a possibility to sell electricity to the market price and minimize the costs for electricity.

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[39] Sture G. Andersson, "Integrating Community Energy Systems, The Role of District Heating." Malmo Energy Company/University of Lund, May 20, 1990, p. 4.

[40] Ibid.

- as a by-product, because of the CHP-arrangement, heat could be distributed and sold within the community and used for many purposes.

Some proven advantages offered by Sweden's CIES compared to individual, on-site building heating systems include:

- better possibilities for energy conservation,
- a higher strategic safety of energy supply as many different fuels can be used in the CIES network,
- environmental benefits, due to the higher efficiency as well as to the possibilities to use more sophisticated cleaning technologies and equipment in large-scale district energy plants,
- the possibilities to use local industrial waste heat as a supplemental heating source in the CIES improves the economics of those industries supplying waste heat and encourages new industries to establish in the area.

Since 1987, Malmo has changed its major CHP plant from heavy oil to natural gas, largely for environmental reasons. This has reduced emission levels substantially. In planning for Malmo's next base load CHP unit, environmental issues are a primary focus. To reduce NO_x emissions, Malmo intends to build a circulating fluidized bed combustion unit. This will also open up possibilities to use biomass as fuel if this should be necessary because of restrictions linked to man-made CO_2 emissions.

Employment

The use of district energy has contributed substantially to regional employment. With prefabricated pipe-systems, about 50 percent of the investment is related to local activities by building contractors, welders, etc.

Expansion of CIES

Malmo has one of the most effective municipally-owned CIES networks in the world--M.E. Malmo Energi AB. This company is responsible for the purchase, production and distribution of electricity, district heating and natural gas.

The number of subscribers is today roughly 8000 with a nominal heat load of 15 MW_{th}. The system operates using plants owned by the community as well as industrial waste heat producers.

On July 1st, 1977, Sweden passed a law which gave the Swedish communities responsibility for energy planning within their areas. This imposes, among other things, the establishment of heat-mapping schemes and the way the energy needed should be supplied. This encouraged the integration of the energy systems of the communities and sped up the cooperation between energy companies and local industries to use waste heat sources.[41]

Due to amendments in the Law on Municipal Energy Planning, Swedish municipalities are charged with the mandate of setting up a plan for the municipal supply, distribution and utilization of energy. The municipal energy plan indicates the local significance of energy issues, and it is based on a comprehensive view.

The Parliament left the municipalities quite free to draw up their own plans on the basis of individual municipal conditions and problems. The Law, however, indicates various matters that have to be considered. The plans are to contain energy-related goals for the municipalities, and these goals must be based on the national energy policy goals, such as promotion of energy efficiency, decreased oil-dependency, and the use of indigenous and renewable supplies. Within these guidelines, the municipalities are free to decide the orientation of their energy plans.[42]

The municipality of Malmo's present plan is indicative of the comprehensiveness of Swedish municipal integrated energy planning:

- the whole energy system (energy supply, distribution and use) is covered by one and the same plan;
- attention must be given to the environmental impacts of energy use;
- the transportation sector shall be included;
- activities in which the Municipality can only indirectly influence energy use must also be accounted for in the municipality's energy plan; and

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[41] Ibid., p. 6.

[42] Energiplan For Malmo, Malmo, Sweden, 26-10-1990, p. 4.

- the energy system must be adapted for increased local generation of electricity--the goal is to reach 1500 GW.h/year or 65-80 percent of Malmo's energy requirements in the year 2000.

Malmo's long-term goal is to conserve non-renewable resources and to have an energy system predominantly based on renewable resources. Malmo's energy generation system will have, by the end of the 1990s, the technical capability to cover three quarters of its district heat requirements with biofuels, waste fuel and waste heat.

Besides being an obligation, the energy plan is also a means for gaining a grasp on the total municipal energy utilization and on its technical, economic, and environmental consequences. The Malmo energy plan indicates the orientation of the Municipality's energy policy and constitutes an instrument for coordinating inputs and improving operations.

II.5 Finland

Finland is a world pioneer in the use of district heat. Almost 35 percent of all Finnish homes are connected to district energy systems and this figure is expected to go up to 50 percent by the end of the century. More than 65 percent of all district heating is produced in combined heat and power plants with CHP's share of total electricity generation currently the highest in the world.[43]

The use of industrial wastes as fuels for process steam production as well as for production of electricity has a long history in the Finnish energy system. Waste fuel use started early in the 1930s; the current share of industrial wastes in total energy supply is 9 percent. The largest share of the wastes is produced by the forest products industries which cover a large portion of their electricity and process heat demands by firing wastes. In some cases, industrial plants also provide neighboring communities with district heat.

The energy situation in Finland is remarkable compared to many other countries:

- The fuel consumption for electricity and district energy is spread over a great variety of energy sources (Table II.1 and II.2).

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[43] *Energy in Finland*, 1988/1989.

- The district energy share of the space heating is very high, while natural gas is little used for space heating.

- The share of CHP is very high and close to the maximum, as only 10 percent of the electric production remains as condensing power stations.

- The industrial share of CHP and district energy is high.

- The total energy consumption is very high per capita.

- Energy taxes are low.

- Finland has no municipal energy planning system, as do Denmark and Sweden.[44]

- End-use energy saving measures have had a low priority.

Energy development in Finland has been based upon a combination of several important features:

- Energy Supply Planning - According to the Electricity Supply Act of 1979 and 1980, the power utilities have to prepare plans for production and supply of electricity including CHP both at the national and at the regional level. The national plan has to be approved by the government and the regional plans have to be approved by the Ministry of Commerce and Industry.

- Nuclear Power - Nuclear energy, while still part of the national energy policy, is not supported by a majority in Parliament.

- More CHP - As a consequence of the nuclear moratorium, the power utilities have given new CHP plants high priority. Generally, the utilities own and operate the plants and sell district energy.

- CHP/CIES Utility - A large, national power utility constructs, owns and operates local CHP plants, and CIES networks as well where the municipalities do not want to be involved in energy supply.

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[44] B. Hojlund Rasmussen Consulting Engineers and Planners A/S, *Review of European Tariff and Regulatory Experience with the Sale of Heat and Electricity from Cogeneration Facilities*, Progress Report, Final Draft, for the Canadian Electrical Association, Prince Edward Island Energy Corporation, August 1991.

- Natural Gas - The national gas company has bought cheap gas from the USSR for many years. The policy of the national gas company has been to sell gas to CIES and power utilities and major consumers, and not to compete with the local district energy utilities in the space heating market.
- Varying Electricity Prices - The public utilities use different levers to promote district energy. One is to charge a higher electricity price for heating in areas supplied by district energy.
- Subsidized Domestic Energy - Domestic energy sources (peat, wood, chip, waste, etc.) are subsidized and are expected to cover most of the energy demand for space heating and industry in Finland, except the southern, densely populated part, by the year 2000.
- Forestry - The forestry industry is highly developed in Finland, with energy intensive industries, using wood chip and waste products to produce CHP.[45]

II.5.1 Combined Heat and Power Production

The most common CHP plant in Finland is a large coal-fuelled plant owned by a power company or by a public utility, distributing both heat and power.

Combined heat and power is highly developed in Finland. The total production capacity in the district energy systems in Finland is approximately 15 000 MW. One third of this capacity is CHP plants, producing two thirds of the total district energy production. The most dominant fuels in the district energy systems, both for CHP and boilers, are coal, peat and natural gas (Table II.1).

There are a total of 165 CHP plants in Finland, of which 112 are for industrial process and only 53 are built for district energy. Some of the 112 industrial CHP plants also produce CHP for district energy as a secondary product or the industry delivers surplus heat from the process.

The types of Finnish district energy organizations are shown in Table II.5.

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[45] Ibid.

TABLE II.5

FINNISH DISTRICT ENERGY ORGANIZATIONS

Type of District Energy Organization	Numbers	Share of Production (percent)
Energy Utility		
Public	32	65
Limited	9	18
Others	6	2
Energy Utility, Total	47	85
District Energy Utility, Only		
Public	23	3
Limited	59	11
Others	2	1
District Energy Utility, Total	85	15
Total	132	100

SOURCE: B. Hojlund Rasmussen Consulting Engineers and Planners A/S, *Review of European Tariff and Regulatory Experience with the Sale of Heat and Electricity from Cogeneration Facilities*, Progress Report, Final Draft, for the Canadian Electrical Association, Prince Edward Island Energy Corporation, August 1991, p. 74.

The expression "energy utility" covers a utility supplying both district energy, electricity and/or gas and water. The district energy company or section will normally be an independent part of the energy utility and buys heat from the CHP plant.

Until now, it has been standard practice for district energy companies to use the profit from investments to lower the heat price. However, it is not illegal to transfer profits to other sections of the public utility and to shareholders, and it might be expected to be more common in the future as the investments in the district energy networks are paid back.[46]

II.5.2 Tariffs

Tariffs for CHP are normally related to the alternative heat cost principle. The district energy utility pays a fixed charge equal to the capital costs and fixed operation and maintenance costs of a district energy boiler, using the same fuel and having the same heat capacity as the CHP plant. The district energy utility pays a variable charge equal to the heat share of the total fuel costs and some of the variable operation costs of the plant. The heat share of the fuel consumption using this principle is almost the same as the fuel consumption would be using boilers for heat production only.

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[46] Ibid.

This simple principle of heat pricing leaves the responsibility for optimal operation and design to the power utility. As long as the total price is low enough to promote district energy and make it competitive compared to alternatives, and as long as there is space for CHP in the power system, the principle seems sufficient.

II.5.3 Taxes

Taxes in Finland are divided into sales taxes and environmental taxes. The sales tax on all energy forms (natural gas, district energy and electricity) is 17 percent of the sales price including tax, corresponding to 20.48 percent of the sales price excluding tax. For natural gas sold to district energy utilities and industries, the sales tax is 2 percent. Domestic fuels are totally exempt from sales tax.

Environmental taxes depend on the carbon content of the fuel (or the CO_2 emission), as shown in Table II.3.

II.6 Canadian CIES Overview

If you ask the average person in Canada about district energy and how and where it is used, you will probably get a blank look; Canadians simply know much about district energy. However, this doesn't mean district energy systems are few within Canada.[47]

Canadian district energy systems range from small complexes with capacities of about 0.5 MW to large systems like those run by the Toronto District Heating Corporation or Central Heat Distribution in Vancouver, which have installed capacities of over 370 MW and 250 MW, respectively. The Canadian Department of National Defense has about 57 systems with a total installed capacity of over 1400 MW. Canadian universities and hospitals with central heating plants number over 60, while federal and provincial government buildings add many more to the list.

It is clear that district energy is used, but not widely recognized, across Canada. While poor recognition attests to good reliability, this low profile has made it difficult to convince policy-makers that district energy could have a more important role to play in Canada's energy-environment-economy future.

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[47] J. Michael Wiggin, Energy, Mines and Resources Canada, "District Heating In Canada: Where We Are and Where We Are Going," *District Heating & Cooling*, Vol. 75, No. 3, First Quarter 1990.

II.6.1 Canadian District Energy Origins

The first district heating system in Canada was established in 1924, serving a small section of the City of Winnipeg's commercial core. Other Canadian cities served today by steam district heating systems are Toronto, Montreal, and Vancouver. The only two hot water district heating systems, using European technology, constructed to date in Canada are at LeBreton Flats, Ottawa (1981) and at Charlottetown (1987).[48]

In Canada, the majority of district energy systems are institutional. While several university systems were built before 1920, a large proportion of today's systems were constructed in the early 1960s. This was a period of major expansion of Canada's university system and government construction. It was also a time when oil prices and interest rates were low. In these expansionary years, the ability to use inexpensive fuel oils justified the capital investment of district energy systems--particularly with "5 percent money".

At first glance, it would appear that increasing energy prices over the last two decades would have improved the feasibility of district energy. However, as fuel prices increased with fuel oil demand, the differential between heavy oil and light oil prices diminished, thus taking the edge off the savings that might have been anticipated. Accordingly, district energy construction dropped off and few new systems have been reported in recent years.

II.6.1.1 What's Happening Now

Its very hard to generalize about the current status of Canadian district energy. Some systems have been allowed to run down and are in danger of being abandoned. However, some investors have been willing to undertake the refurbishment costs necessary to revitalize the systems. Trigen Energy Corporation's purchase of Cities Heating Company Limited in London, Ontario is a recent example. Generally speaking, most systems across Canada have been well-maintained and every year sees a steady stream of older system repair and small system expansion.

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[48] Edmonton Power, "District Energy, An Energy Initiative of Edmonton Power," City of Edmonton, District Energy Development Phase, September 1991.

In the federal government systems, there has been much debate about the refurbishment or replacement of central heating plants with individual building heating systems. While some systems have been replaced, the focus now seems to be on renovation.

The Department of National Defense (DND) has been examining hot water distribution technology as an alternative for some bases where older systems need renovation. There appears to be potential for reduced operating costs even though the initial cost of conversion to hot water might be higher than refurbishing some of the steam systems.

II.6.2 Charlottetown, Prince Edward Island

As the first multi-subscriber system in Canada to use European medium-temperature hot water distribution technology, the Charlottetown systems receives considerable attention, particularly in Atlantic Canada. The demonstrated economic and environmental benefits of hot water district heating have caused many municipal officials to reconsider district energy in a broader context. The renewed commitment to environmental enhancement combined with economic development is breathing fresh interest into the application of district heating technology in Canada.[49]

P.E.I. Energy Corporation, established in 1979 with the mandate to identify and demonstrate approaches to use energy more efficiently, has played a lead role in bringing European technology and integrated energy planning to Canada. The P.E.I. Energy Corporation has been responsible for the development of energy systems in the province of Prince Edward Island. As a provincial crown corporation, the Corporation has had a mandate to consider the broader benefits of implementing district heating. Charlottetown's district heating system demonstrates that medium-temperature hot water district heating can be used in Canada and that municipalities can experience the same benefits as those in Europe.[50]

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[49] J. Michael Wiggin, Energy, Mines and Resources Canada, "District Heating In Canada: Where We Are and Where We Are Going," *District Heating & Cooling*, Vol. 75, No. 3, First Quarter 1990.

[50] P.E.I. Energy Corporation, *Annual Report*, 1989-1990. See also Rob Brandon, Prince Edward Island Energy Corporation, *District*

The Corporation's experience in district energy continues to be of interest to other organizations in Canada. A total of 20 700 tonnes of wood fuel is estimated to have been used in provincial institutions annually. The P.E.I. Energy Corporation owns and operates two district heating systems in Charlottetown totalling 23 MW_{th}, serving forty customers. They are in an active planning stage for a 29 MWe CHP plant that would serve the 60 MW_{th} Charlottetown thermal market. This project is being developed in association with the local utility, Maritime Electric.[51]

II.6.2.1 Downtown District Heating System

On P.E.I., wood chips are the primary district heating fuel. Whole tree wood chips, chips made from harvesting, sawmill residues and sawdust, and municipal waste are also used to a limited extent. Hot water is the distribution medium in most P.E.I. systems. The heat distribution system involves a network of buried insulated pipes that carry hot water from the heat source to subscribers' buildings.

The present Charlottetown system is a 1.8 MW wood chip-fueled boiler housed in the boiler room of the Prince Edward Home for the Aged. City Hall, the provincial government buildings, the fire hall, and a number of downtown hotels and businesses are connected to the hot water distribution network. Prince Edward Island's community integrated energy system was designed so that it can be interconnected with a larger-scale district energy network in the future.

In 1991, the P.E.I. Housing Corporation and the developers of the Royal Trust Tower both approached the P.E.I. Energy Corporation to have their new buildings connected to the district energy system. The Corporation developed an extension that saw the construction of a 150 mm (dia) line along Rochford Street to the MacMillan Building and the Old Charlottetown Hospital, which has significant surplus boiler capacity. Connecting this additional boiler capacity allowed the pipeline system to be extended along Kent Street to the intersection of Kent and University Avenue. Four additional substations were installed to serve the heat load along Kent Street, including the Confederation Court Mall. For the extension along Kent Street, a cost sharing agreement was arranged with Maritime Electric to install lighting and power cables in the district heating trench.

Heating in Charlottetown, Integrated Energy Systems Opportunities Conference, Edmonton, Alberta, February 19, 1992.

[51] Rob Brandon, personal correspondence, October 2, 1990.

II.6.2.2 University District Energy System

The University of Prince Edward Island (UPEI) district energy system produces enough heat for the campus buildings and for 27 other subscribers' buildings. It has a 3.7 MW biomass-fueled boiler that uses 10 000 green tonnes of wood chips annually to displace 2.2 million litres of imported fuel oil. This project is one of the largest hot-water district heating systems in Canada.

The energy savings resulting from the conversion of the University steam system to a hot water system have been higher than estimated, at over $90 000 per year. Lower than anticipated oil prices, however, are of concern since district energy revenues from private sector customers are linked to light oil prices.

During 1991, an assessment of the system peak load and the boiler capacity at UPEI was carried out. There were 6782 MW.h of energy savings identified from the conversion of the University system to hot water district heating, worth $98 037.

II.6.2.3 Energy-From-Waste Plant

The Energy-From-Waste plant consumed 31 000 metric tonnes of municipal waste in 1989-1990 and sold 37.4 million kg of steam to the Queen Elizabeth Hospital (QEH). The steam is estimated to have displaced about 3.2 million litres of light fuel oil worth $614 000. The plant has a back-pressure steam turbine that produced 597 MW.h or about 38 percent of the plant's power use. In the seven years since it started operation, all available refuse totalling over 200 000 tonnes has been processed for the Greater Charlottetown community, resulting in steam sales of over 230 million kg. Oil saving during the period has totalled approximately 20 million litres of light oil.[52]

A study is underway to determine the potential excess energy available from the plant and the feasibility of piping this energy to the University district heating system.

Combined heat and power, now possible as a result of the growing district heating systems, is an active possibility as the corporation seeks to further realize the benefits for the local economy.

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[52] P.E.I. Energy Corporation, *Annual Report*, 1989-1990.

II.6.2.4 Projects Under Development

Charlottetown District Heating System

The P.E.I. Government intends to pursue the option of Island power generation--the Charlottetown CHP project--via a 29 MWe power plant using wood and oil as fuel. The power plant will serve an expanded district heating system. In support of this initiative, a number of studies were started in 1991. They included a full review of the Charlottetown heat load in order to assess the viability of an expanded district energy network. Also, a collaborative effort was started by the Corporation involving the City, the Charlottetown Water Commission, the Public Utilities Commission, Maritime Electric and Island Telephone to review the potential of an integrated Geographic Information System for underground facilities.[53]

II.6.2.5 CIES Benefits

Indicative of the benefits of district energy to P.E.I. is that CIES is used to displace imported oil with a readily available home grown fuel--wood chips.

District heating has been an integral part of the provincial economic development and environment strategy. By assembling a heat load, it has been possible to cost effectively burn wood chips and thus provide a basis for a local wood fuel industry. Furthermore, wood fuel burning, combined with sustainable yield forestry practices, has a neutral CO_2 impact on the environment since carbon dioxide is fixed in growing trees at the same rate as it is released through combustion.[54]

In addition to the energy efficiency benefits provided by district energy, these systems can provide important social benefits. For example, using municipal solid waste to generate heat and power in incinerators can assist in the management of an environmental problem of growing concern. In other cases, a locally available source can be used to displace costly fuel oil supplies. For example, in the case of Charlottetown, a wood-fuelled base-load plant is contributing to the development of an indigenous fuel supply system, generating employment and reducing the amount of energy imported by P.E.I. This makes P.E.I. a bit more independent and it also creates rural employment. Importantly, it also keeps local dollars in the local economy. For example, when P.E.I. uses oil for heating only 5 cents of each dollar stays on the Island, but when biomass is used for CIES, seventy cents stays on the Island.[55]

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[53] Ibid.

[54] J. Michael Wiggin, Energy, Mines and Resources Canada, "District Heating In Canada: Where We Are and Where We Are Going," *District Heating & Cooling*, Vol. 75, No. 3, First Quarter 1990.

Charlottetown is also using its waste in the Parkdale incinerator to generate steam used to run the heating systems for the Queen Elizabeth and Riverside hospitals, savings the two institutions about 3.3 million litres of heating oil each year. Sending the waste to the incinerator has helped reduce the volume of garbage going to landfill sites by 90 percent.

II.7 Toronto, Ontario

II.7.1 CIES in Toronto Today

Toronto's district energy roots go back to a public interest issue of the early 1960s. At that time, Toronto City Council was concerned about the proliferation of smoke stacks and coal- and oil-fired heating plants in the downtown core. It directed Toronto Hydro, its publicly-owned electric distribution company, to undertake a district heating feasibility study for the downtown core. The results showed that district heating could reduce multiple coal- and oil-fired boiler plant operations and Toronto City Council therefore mandated Toronto Hydro (TH) to make district heating a reality.

First, the City created a new operating company, the Toronto District Heating Corporation (TDHC). TDHC took over control of all of the assets and liabilities of Toronto Hydro's Steam Division (also a city-owned entity). There was no purchase; simply a transfer of responsibility between publicly owned companies. This was followed by the integration of the Walton Street Plant, owned and operated by a provincially-chartered, non-profit consortium of seven hospitals. Next came the interconnection with the Queen's Park system.[56]

The hospital consortium turned over their heating plant in return for a guaranteed steam price. The guarantee stipulated that the price the hospitals would pay to TDHC would be no different than if they had produced the steam it themselves.

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[55] Brochure, District Heating--The Prince Edward Island Experience.

[56] Kevin Knox, Toronto District Heating Company, "Consolidated District Heating (& Cooling): Public Interest, Public Purpose, Public Policy, Public Good," *District Heating and Cooling*, Vol. 75, No. 3, First Quarter, 1990.

The Province of Ontario was also a key element. In addition to shutting down its plant in favour of purchasing steam, the Provincial Government provided a capital grant for the interconnecting piping between the Queen's Park system and the TDHC system. As with the hospitals, Queen's Park purchase price was to be the same as if it were producing its own steam. The University of Toronto and Toronto Terminal Railways both later became part of the integrated TDHC system.

Although Toronto Terminal Railways participated wholeheartedly in the study, in 1974 it decided to stay independent and continue operating its own steam generating plant. At that time, its annual production was about 600 000 Mlbs, and its customers included railway operations and offices, hotels and federal buildings. However, by 1986, its production had fallen to about 300 000 Mlbs per year, with major capital expenditures on the horizon. As a result, the Railway closed its plant and converted its customers to the TDHC system. The facility is scheduled for demolition, and site redevelopment plans are underway.

Since off-peak electrical power purchased by TH from Ontario Hydro was a good buy at the time, the initial district energy system used electricity to make steam at the central heating plant. Steam produced in electric boilers during the off-peak hours was used to charge a steam accumulator, a thermal storage device. While the idea was sound, technical problems with the steam accumulator led to the change to an oil-fired burner plant at Pearl Street.[57]

During the first eight years of operation (1964-1972), Toronto's district energy network experienced terrific growth. District heating was popular because it provided customers with an economical way of decommissioning individual-building heating plants. From an initial customer base of zero, sales grew to 1.2 billion pounds of steam by 1972. Toronto Hydro accomplished the City's vision, but it was growth itself that proved the next hurdle for Toronto's district energy development.

Toronto proved to be a popular business and retail center, a nice place to live and work, and a good place for real estate investments. New buildings were built, and more and more people were attracted to Toronto, so more buildings were built. This proved to be good news for district heating sales, but bad news from the operations perspective.

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[57] Ibid.

Many of the buildings constructed during these high growth years were located near the district heating system's oil-fired Pearl Street Plant. So close in fact, that the plant was becoming overwhelmed by structures taller than its stacks. What had originally been a suitable site in the early 1960s, became an environmental issue and once again, Toronto's City Council had to respond. At the same time, competition from other heating supply alternatives was beginning to make inroads into the downtown heating market.

In 1972, Toronto City Council commissioned a study to investigate the environmental, engineering and economic issues associated with the location of tall stacks in association with urban development. In addition, the growing metropolis was creating increasing amounts of refuse that was being hauled to landfills. All of these factors plus district heating equaled an opportunity for Toronto's future. Some envisioned burning the community's refuse outside downtown, thereby improving the air quality and reducing the impact of the tall downtown stacks, while providing a new, renewable energy source for district heating.

When Toronto Hydro's district heating system was created, several other systems were being independently operated by a group of downtown hospitals, the Province of Ontario at Queen's Park, the Toronto Terminal Railway, and the University of Toronto. The study commissioned by the City in 1972 produced a grand plan for an integrated community energy system. The recommendation was that all of the existing downtown district heating systems be connected into a single production and distribution network. The network would more effectively use existing production facilities, reduce urban air pollution and defer capital expenditures on new boilers, because adequate capacity could be tapped within the network. Most importantly, it could provide sufficient base load for a large, modern waste-to-energy steam plant.

The grand plan that recommended the interconnection of the existing district heating resources also proposed waste as a future steam source. This became particularly important since the integration meant all plants were needed to meet capacity and peaking and standby requirements. As a result, the City agreed that once the new company was formed, and the overall integration was completed, it would begin to develop a refuse-fired steam plant. The site was to be constructed on property already owned by the City, about four miles from the TDHC system. The distance was right, the site was right, and the amount of the annual steam sales was right for a 1500-ton-per-day plant (1270 tonnes). But the plant has yet to become a reality.

Although heroic efforts and public good resulted in an integrated, consolidated district heating system, other developments occurred near enough to the proposed site to preclude the waste-to-energy plant's development. It had taken eight years from the start of the study to install the last piece of interconnecting pipe. In those eight years, land uses had shifted and what was primarily an industrial area became a residential community. These changes meant that the energy-from-waste plant would have to be sited further away--beyond an economic distance to transport steam. While hot water can be economically transported further than steam, Toronto's district energy market is steam-based and conversion costs to hot water could be substantial. This experience points to the need to thoroughly consider a longer-than-typical planning scenario to ensure that important opportunities are not lost as in Toronto.

Today, TDHC enjoys annual steam sales of 2.2 billion pounds, making it one of the largest district heating companies in North America. It continues to rely on the Walton and Pearl Street Plants and the trading agreement with the University of Toronto. Capacity considerations are a concern as the possibilities for new customers are considered. Not wanting to accept this limitation for downtown Toronto, the City is actively looking at natural gas-fired CHP. This time another but different partnership is being considered. Since the probability is strong that a site for a gas-fired plant can be found, the City through TDHC is looking for a private investor as a partner in combined heat and power generation.

While TDHC prefers not to be in the electric utility business, it recognizes the economic and environmental benefits of CHP applications. Hard work, a concern for the urban environment and a commitment to a secure energy future, have enabled Toronto to develop an integrated community energy system that brings environmental and energy efficiency benefits to its downtown core. But, the benefits of CIES did not come about by accident. They came about because public interest, public purpose and public policy produced something for the public good.

II.7.2 Toronto's CIES Future

Owing to the growth in Ontario's electrical demand and concern about the environmental impacts of electricity generation, deep lake water cooling (DLWC) is being seriously assessed as a CIES option in Toronto.

This concept involves pumping 4°C water from a depth of about 70 m in Lake Ontario, that would require as little as 5 percent of the electricity used by chillers. Chillers currently run at a rate, and for a duration, equivalent to running at full load 11.4 percent of the time (1000 hours per year). Because the surface water of Lake Ontario cools to 4°C each winter and sinks at that temperature, the cold deep water in the lake represents a renewable heat sink. Used water from the cooling system would be returned to the lake at close to ambient lake water temperatures and would therefore have considerably less impact on lake temperature than the water used to cool the electric power generators that would no longer be needed as a result of DLWC.

Deep Lake Water Cooling is a method of cooling buildings first proposed by Engineering Interface Ltd. (EIL) in 1981. DLWC involves using the naturally cold water deep in Lake Ontario to cool buildings in the Toronto city core. The concept includes construction of a long intake tunnel beneath the lake bed to a pumping station on shore.[58]

Office cooling requirements are a result of heat gain from office and other equipment, sunlight through windows, outside air, and occupants. Although advances in equipment design may decrease the heat emitted, the increasing use of electronic equipment could increase the demand for cooling in downtown Toronto buildings.

Buildings in the area bounded by Queen's Quay, Bloor Street, Jarvis Street, and Spadina Avenue would be served by a grid of tunnels and branch lines. The pumping station would distribute cold water to heat exchangers within each building and warm water would be returned to the Lake Ontario. This method of providing naturally cold water to downtown buildings would decrease the need for the current system of individual, electrically-driven chillers that use coolants containing CFCs that are to be phased out in Canada by 1995 due to their ozone depleting characteristics.

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[58] Canadian Urban Institute, "Deep Lake Water Cooling (DLWC)," Report on the DLWC Conference and Charrette held on June 16, 17, and 18, 1991, Toronto, Ontario, June 19, 1991, p. 4.

II.7.3 DLWC Status

Engineering Interface Ltd. has developed a preliminary design for each of the components of the project.

According to EIL's concept, 4°C water from 80 metres below the lake surface will be drawn through a tunnel to a pump house on the waterfront. The tunnel will be 4.3 metres in diameter, 6.0 kilometres long and 15 metres below the lake bed. Supply and return tunnels, 2.1 to 3.0 metres in diameter, will run through the rock below Yonge Street and University Avenue. Branch lines will be microtunnelled beneath 18 east-west main streets between Spadina Avenue and Jarvis Street.[59]

Naturally cold water will be pumped to buildings connected to the branch lines. The chillers in the buildings will be replaced with heat exchangers that will cool the circulation systems in the buildings. The replacement is expensive. However, the heat exchangers will occupy much less space than the chillers and will require less maintenance.

The system has been designed for an anticipated demand of 300 000 tons of cooling expected in 2015 (ton of cooling is an engineering term for a rate of cooling that requires close to 1 kilowatt of electricity to produce). In 1991, 200 000 tons of cooling will be required to cool the buildings in the area.[60]

The temperature of the outfall water will be between 10°C and 12.5°C. EIL has proposed that the warmer water be discharged into the Inner Harbour. About 30 percent of the energy input will be recovered as the water returns to the pumping station site--by means of four turbines driving electric generators.

A survey has established that DLWC has a high degree of acceptability to potential downtown customers.

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[59] Ibid., p. 6.
[60] Ibid., p. 7.

II.7.3.1 Displacement of Emissions

Two potential environmental benefits of the DLWC proposal are the reduction of emissions associated with the generation of electricity, and a decreased reliance on CFCs presently used as refrigerants in chillers.

Ontario Hydro's peak energy demand periods coincide with cooling load maximums. Generating plants such as Lakeview that rely on fossil fuels are used by Ontario Hydro as peaking plants.[61] The reduction in carbon dioxide emissions resulting from a DLWC system is estimated at 146 000 tonnes per year--not insignificant, but only 0.5 percent of the total CO_2 emission from coal-fired generating plants in Ontario of 28 million tonnes per year. Methane and nitrous oxide, more potent greenhouse gases than CO_2, would also be reduced. Use of CFCs, that contribute both to stratospheric ozone destruction and to the enhanced greenhouse effect, could be virtually eliminated in the area served by DLWC.

Use of deep Lake Ontario water within the existing district heating/cooling distribution system would reduce peak electricity demand by 200 MW and reduce total annual electricity demands by about 2 percent. Were the existing district heating/cooling system to be extended into new or existing developments not yet served, the avoided electricity demand and CO_2 emissions would be even larger.

If warming of the planet does indeed occur as a result of the greenhouse effect in coming decades, the demand for cooling and avoided energy use with DLWC will be larger still. DLWC provides a CFC-free cooling method. The leakage of CFC's from the chillers that DLWC would displace contributes about as much to the strengthening of the natural greenhouse effect as the generation of the electricity used to power the chillers. Over the 10-15 lifetime of technologies such as chillers, the greenhouse effect of CFC leakage is therefore somewhat greater than that of the CO_2 released in supplying the electricity to the chillers. Hence, the greenhouse reduction benefit of DLWC applied to Toronto's present district heating and cooling system is about twice as great as based on the 200 MW power savings alone.

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[61] Ontario Hydro has cautioned that a direct link between fossil-fuel use and peak-demand periods is not possible, and that by the time DLWC would be implemented coal-fired facilities may no longer be in use.

Further potential energy and greenhouse savings from DLWC arise because less energy would be needed for deoxygenating the water before using it as a coolant than at present--because deep lake water is already low in oxygen--and the return water could be used to supply drinking water, requiring less energy for purification than the more polluted surface lake water that is presently used in Toronto.[62]

Although CFC substitutes are under development, these substitutes have a negligible ozone depletion and greenhouse gas potential. Hence we will be no better off than at present if , as a result of Third World development and expanded use in developed countries, total global production of the substitutes reaches pre-Montreal Protocol CFC production rates.[63]

II.7.3.2 Financing and Managing DLWC

Options regarding the question of ownership and management of DLWC include:

- A municipal corporation
- Toronto Hydro
- A specially established provincial crown corporation
- Ontario Hydro
- A business corporation
- A combination of the above.

In each case, the proponents will be accepting the risk of a deficit, as well as the potential benefits. The manner of ownership will determine the extent of taxes paid to various levels of government.

Also related to proponency is the cost of borrowing, which would be high but less expensive for a provincial agency. Consequently, 'profit' potential is higher for a provincial crown corporation than for a municipal corporation. There may be public resistance to an already large and powerful corporation such as Ontario Hydro becoming larger and more powerful. A private venture may be most susceptible to demands for expansion of the system should DLWC be a success. Expansion may not be in the public interest if other options could meet the demand for cooling at a lower environmental cost. A business corporation may be the most adept at exercising discipline with respect to controlling costs.

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[62] City of Toronto, "The Changing Atmosphere: Strategies for Reducing CO_2 Emissions, Technical Volume," Special Advisory Committee on the Environment, Report No. 2, Vol. 2, Toronto, Ontario, March 1991, p. 28-35.

[63] Ibid.

Tenants and building owners would prefer an ownership scheme that would minimize their costs. However, it is not possible to draw clear relationships between DLWC rates and the ownership options.

The length of the environmental approval process will be the determining factor in construction scheduling and therefore cost. The proposed schedule allows three years for environmental assessment. However, cost estimates are based on a pessimistic schedule that involves a 1997-1998 construction start.

Before accounting for a subsidy by Ontario Hydro, the cost of DLWC is estimated at $611 000 000. The net cost after incorporating the Ontario Hydro thermal storage incentive of $400 per kilowatt is $475 751 800.[64]

II.7.3.3 DLWC Alternatives

Various alternatives to DLWC exist:

- One is to do nothing, but this is becoming increasing unsupportable as concerns rise about the emissions from the fossil-fuel combustion used to generate some of the electricity that drives the present chillers, and about the use of CFCs in the chillers.
- The second alternative involves reducing the amount of cooling that is needed either by reducing expectations about the living and working environment or by reducing heat gain within buildings, or by doing both.
- The third alternative involves cooling with other, more benign methods. These might include generating electricity for cooling with fuels other than coal, notably natural gas using absorption chillers that use hot water or steam rather than electricity.

At the end of 1991, discussions amongst the DLWC study proponents continued and further study is underway on outstanding issues and examination of DLWC alternatives. Interested parties are encouraged to contact the Canadian Urban Institute or CANMET for additional information (see Appendix D).

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[64] Canadian Urban Institute, "Deep Lake Water Cooling (DLWC)," Report on the DLWC Conference and Charrette held on June 16, 17, and 18, 1991, Toronto, Ontario, June 19, 1991, p. 11.

II.7.4 City of Toronto Special Advisory Committee on the Environment

As part of its commitment to reducing greenhouse gases (GHG) by 20 percent, the City of Toronto established a special advisory committee to advise it on various GHG strategies. The following text presents some conclusions and recommendations made in the Committee's recent report.

Toronto City Council has indicated that it views favourably the idea of development charges to pay for a community integrated energy system in the Railways Lands, and potential users of the Railway Lands accept the idea of district heating and cooling. However, one of the key problems is uncertainty concerning the choice of sites for the power plants and whether sites will be approved by City Council.

The Special Advisory Committee emphasized that district heating and CHP involve the same natural gas that would otherwise be used by heating systems in individual buildings, except that the overall efficiency is greater and emissions of NO_x can be more easily and rigorously controlled. A small number of intermediate sized plants could be located underneath planned developments, and chimneys incorporated into the building structure so as to ensure adequate dispersal of those emissions that do occur in an aesthetically acceptable manner.[65]

The Special Advisory Committee On the Environment specifically recommended:

- that Toronto City Council clearly indicate that it wishes to see significant expansion of the district heating and cooling system, in conjunction with electricity CHP and possibly with DLWC, and that it intends to approve the necessary siting of power plants;
- that Toronto City Council proceed with expansion of a district heating and cooling infrastructure, to

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[65] City of Toronto, "The Changing Atmosphere: Strategies for Reducing CO_2 Emissions, Technical Volume," Special Advisory Committee on the Environment, Report No. 2, Vol. 2, Toronto, Ontario, March 1991, p. 28-35.

include major new developments once feasibility studies prove positive;

- that Toronto City Council levy a charge on new developments to pay for the district energy infrastructure;
- that Toronto City Council set up an agency to raise additional capital required for expansion of the district heating and cooling system;
- that Toronto City Council concurrently fund and further feasibility studies and environmental impact assessments for DLWC;
- that Toronto City Council fund further feasibility studies for the use of wastewater as a heat source in winter and as a heat sink in summer, as part of an integrated community heating and cooling system that might also use DLWC; and
- that Toronto City Council ensure that new developments to be added to the district heating and cooling system meet the highest possible energy efficiency standards, and that individual customers are individually metered, so that the incremental increase in the heating and cooling load of new and existing buildings will be as small as possible.

The Committee concluded that there are several economic factors that favour expansion of Toronto's existing district energy system now:

- the development levy could be such that the district energy system would entirely pay for itself, yet this levy would be offset by the fact that individual heating systems (that tend to be costly) would not be needed, and through reduced energy use;
- installation of district heating and cooling with CHP and possibly DLWC will be much cheaper now, while substantial further developments are yet to occur, than in the future after these developments have been completed;
- CFC substitutes will generally require retrofitting or replacement of existing chillers over the next few years. Hence much of the existing cooling equipment that would be rendered unnecessary if existing buildings used DLWC will have to be prematurely retired or retrofitted anyway. Therefore, only a portion of the cost of premature retirement of

existing chillers and possibly none of the cost should be ascribed to DLWC;

- as DLWC will substantially reduce peak electricity loads, it is eligible for funding by Ontario Hydro of up to $100 million--assuming 200 MW displaced peak load;
- there are tremendous benefits to expanding the present district heating system and using it as a district cooling system in summer irrespective of whether or not DLWC is part of the system; and
- although CHP is highly attractive from both an economic and environmental point of view, its development might be inhibited by regulatory uncertainty. Toronto City Council must therefore clearly articulate its support for local CHP of electricity and for expeditious environmental reviews. Expansion of Toronto's district heating and cooling system, in conjunction with electricity CHP and with or without DLWC, offers the opportunity for significant environmental benefits and energy savings at no cost to the taxpayer. Such opportunities are rare, and cannot be allowed to slip away.

As well, there may be opportunities for industrial CHP within Toronto; such opportunities should be investigated. Natural gas-powered fuel cells, that have just become commercially available, may become an economically attractive means of cogenerating heat and electricity. Fuel cells promise quieter operation than existing natural gas-turbine CHP systems, and essentially zero pollutant emissions. The Special Advisory Committee therefore recommended that Toronto City Council solicit support from Ontario Hydro and Consumer's Gas in setting up a fuel cell demonstration for electricity and heat.[66]

Even when energy efficiency measures result in lower life-cycle costs, there can still be substantial upfront costs. These can be met in part through incentive programs offered by Ontario Hydro, Toronto Hydro, and Consumer's Gas; through private energy service companies; and by tapping investment funds and private capital.

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[66] Ibid.

II.7.4.1 Changing Toronto Hydro's Mission

Achieving the City of Toronto's 20 percent CO_2 emission reduction target will be facilitated through the active assistance of Toronto Hydro. This means that there is a need for a change in Toronto Hydro's corporate mission. This new mission should be to help its customers meet their energy service needs at the lowest possible social (economic and environmental) cost.

To achieve this goal, Toronto Hydro should:

- encourage increased efficiency in the use of electricity through rate reforms, public information programs and incentive programs;
- purchase electricity from independent power producers (such as natural gas CHP facilities) whenever such purchases are a cost effective means of reducing CO_2 emissions; and
- promote substitution of natural gas for electricity when this can be shown to reduce CO_2 emissions.

To achieve these goals in a cost effective manner, it will be necessary for Toronto Hydro to quantify the electricity end-use of its customers and its marginal cost of meeting different loads (e.g., space heating, lighting).

The transformation of Toronto Hydro into an energy service company implies a fundamental change in the relationship between Toronto Hydro and Ontario Hydro. In particular, it would be in the public interest to develop a mechanism whereby Ontario Hydro can buy conservation services from municipal utilities at an avoided cost that reflects full societal costs including environmental costs.

The Special Committee on the Environment urges rapid implementation of the following:

- elimination of the decreasing block rate structure;
- elimination of the minimum monthly bill;
- abolition of flat rate service for water heating; and
- development of other pricing mechanisms that will induce greater conservation of electricity.[67]

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[67] Ibid., p. 14.

To complement the strategy of gradually increasing electricity prices and to assist consumers in maintaining constant or at least slowing increasing electricity bills in the face of an increasing unit price, Toronto Hydro in coordination with Ontario Hydro should provide financial incentives to customers to help them in meeting the cost of replacing inefficient equipment with state-of-the-art equipment. The incentives might require paying up to 100 percent of the cost of energy efficiency measures in order to overcome market barriers.

Toronto Hydro should be given the option of paying for efficiency investments by borrowing in order to minimize rate shock and to recover over the lifetime of the investments. At present, Toronto Hydro must treat energy efficiency investments as operating costs that must be recovered during the year in that they are made.

The Special Advisory Committee therefore urges:

- the provincial Power Corporation Act be modified to allow efficiency investments to be treated as capital investments, so that Toronto Hydro can borrow to finance these investments as assets.

Toronto Hydro should seek financing from Ontario Hydro of as many of its energy efficiency programs as possible; ideally, Ontario Hydro should finance all of Toronto Hydro's CO_2 emission reduction policies as these will reduce the need for new generation and transmission facilities. In this case, Toronto Hydro would not need to borrow at all. However, Ontario Hydro's avoided cost calculations do not include externalities, except for a 10 percent credit for renewable supplies but not for conservation. Until that policy changes, Toronto Hydro may have to finance some of the programs required to reach City Council's 20 percent goal.

II.7.4.2 Toronto District Heating Corporation

If the Toronto District Heating Corporation evolves from its present configuration as a distributor of centrally generated heat to a collector and distributor of dispersed heat sources, then CHP units in individual buildings would comprise part of a larger district heating system. A district energy system could become a broker of heat energy, collecting waste heat from whatever sources are available and delivering it to wherever the heat is needed. The CIES network could not only utilize waste heat from electricity generation but from other sources such as wastewater, subways, dry cleaners, bakeries, and heat that is currently vented to the atmosphere from large buildings. The centralized boilers in Toronto's current district heating system would increasingly serve as a backup unit or supplemental heat source, used only when other sources are inadequate.

II.7.4.3 Integrated Resource Planning

The Ontario Energy Board (OEB) has traditionally been of the view that Consumer's Gas' prime function should be to distribute natural gas, not to promote energy efficiency and conservation or engage in research. However, as a result of heightened public concern about environment issues in general and global warming in particular, the OEB has decided to hold a hearing in 1992 with respect to integrated resource planning in Ontario's natural gas utilities.

The IRP hearing will determine the extent to which Consumer's Gas should be a conservation utility as well as a natural gas distribution utility. In addition, the hearing will determine if the OEBs principles of natural gas regulation should be reformed to ensure that the aggressive promotion of energy efficiency and conservation is in Consumer's Gas interest.[68]

The City of Toronto's strategy to reduce natural gas-related CO_2 emissions would be greatly facilitated if the OEB decides that Consumer's Gas mandate should be expanded to include aggressive promotion of energy efficiency and conservation.

Therefore, the Special Advisory Committee recommended that the City of Toronto pursue:

- a ruling by the OEB that the mandate of Consumer's gas should include the aggressive promotion of energy efficiency and conservation in addition to its service role as a natural gas distributor; and
- the establishment by the OEB of rate making mechanisms that will ensure that the aggressive promotion of energy efficiency and conservation by Consumer's Gas is in the interest of Consumer's shareholders.

Among the opportunities already available for savings in natural gas use, or reductions in future increases from new customers, are: use of high efficiency furnaces; use of high efficiency natural gas water heaters; use of low-flow showerheads; and use of state-of-the-art windows, building insulation, ventilation heat recovery, and passive solar controls in place of standard practice.

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[68] Ibid., p. 24.

II.7.4.4 City of Toronto Department of Public Works and the Environment

Incentive programs could take the form of low interest financing, cash rebates, or leasing arrangements so that the customer does not have to assume the upfront costs. The Committee urges that the Department of Public Works and the Environment of the City of Toronto undertake several conversion demonstration projects for representative building types as soon as possible. At least one of the projects should incorporate a natural gas CHP system that uses the heat from the combustion process for space heating during the winter, and absorption cooling during the summer. Substantial financial support should be available from Ontario Hydro for such an effort to help offset the high initial investment required by the City.

II.7.4.5 Taxing Fuel Use for Trees

Given that existing and any future trees lead to substantial heating and cooling energy cost savings and that fossil energy use contributes to the future warming that necessitates increasing the City's urban forest, the Committee believes that it is perfectly reasonable to raise the required additional funding through a levy on energy use. The Committee therefore recommends that a small surcharge be levied on electricity and natural gas consumption in the city, and on heating oil, to pay for a major expansion of the City's urban shade tree planting program and for improved maintenance of the existing urban forest.[69]

II.8 Edmonton, Alberta[70]

II.8.1 Overview

Edmonton Power (EP) has been developing a major CHP-based community integrated energy project for the Edmonton downtown core over the last few years. The project will initially be 230 MW (thermal) heating and 100 MW cooling with the potential to expand to about 400 MW heating over the next ten years. The district energy will be produced using natural gas.

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[69] Ibid., p. 59.

[70] Information presented in this section was condensed from Edmonton Power, City of Edmonton, *District Energy Development Phase, Engineering Report*, Sections 2, 4, and 7, September 1991.

Edmonton Power's interest in developing a CIES for downtown Edmonton stems from the Federal government commitment to stabilizing greenhouse gas emissions at 1990 levels by 2000. Edmonton Power therefore believes it prudent that long-term planning by all Canada's utilities consider the implications of capped GHG emissions.

Edmonton Power believes that there are three approaches it can take to deal with the GHG issue:

(1) make electricity more efficiently;
(2) institute demand-side management incentives; and
(3) become combined heat and power generators.

When EP looked at district energy, it found that not only did it provide an opportunity to cogenerate but it provided a demand-side management opportunity through the use of heat-based district cooling to eliminate a large electrical summer load and offered an opportunity to make electricity more efficiently by repowering old turbines to combined cycles. By taking these initiatives, Edmonton Power can **significantly** reduce its CO_2 emissions from generating electricity. On the DSM side, district energy allows about 15 MW of electricity presently used for electric chillers to be displaced.

Moreover, **district energy** is the best cogenerator available as it is highly efficient, well suited to electrical generation, and a base load supplier--**not** process based.

Edmonton Power believes that as Canada's electric utilities are well suited to accommodate capital risk, they should be willing to adopt the long-term vision to go ahead and offer electricity **and** heat to Canadians.[71] Community integrated energy systems offer EP the opportunity to make electricity better--overall thermal efficiency of existing units at the Rossdale station would be improved from about 30 percent to 70 percent (see Figure II.1), with repowering to combined cycles. In the future, efficiencies would be further improved to perhaps 85 percent or better.

What makes the Edmonton downtown, Rossdale station so suitable for conversion to CHP is that it is a peaking station--the

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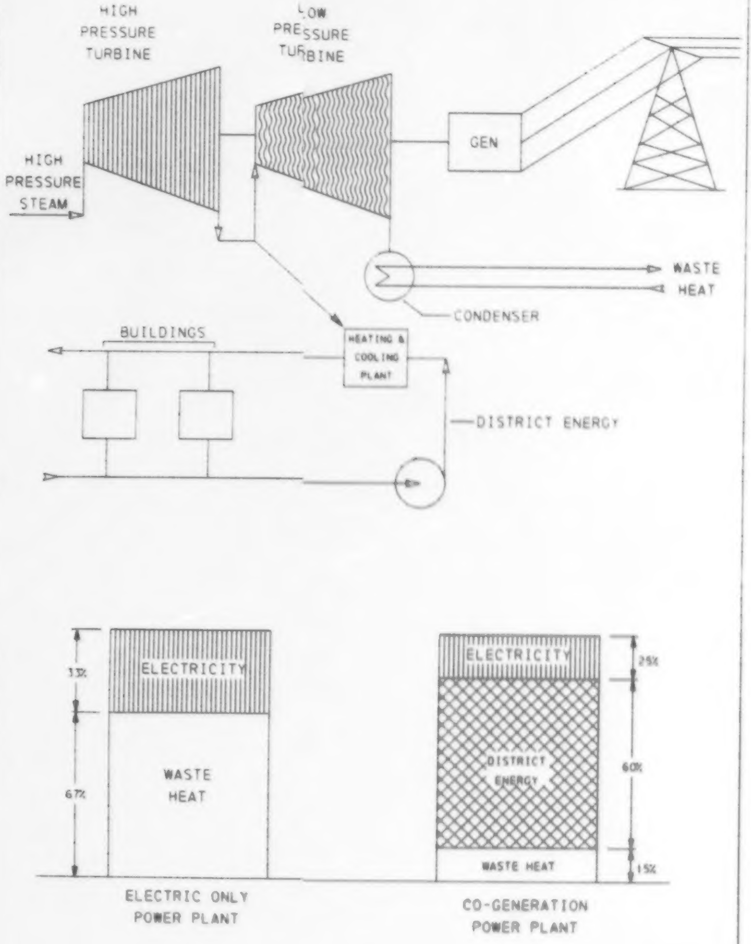
[71] Interestingly, this view was also a major recommendation in a recent House of Commons Standing Committee on the Environment report.

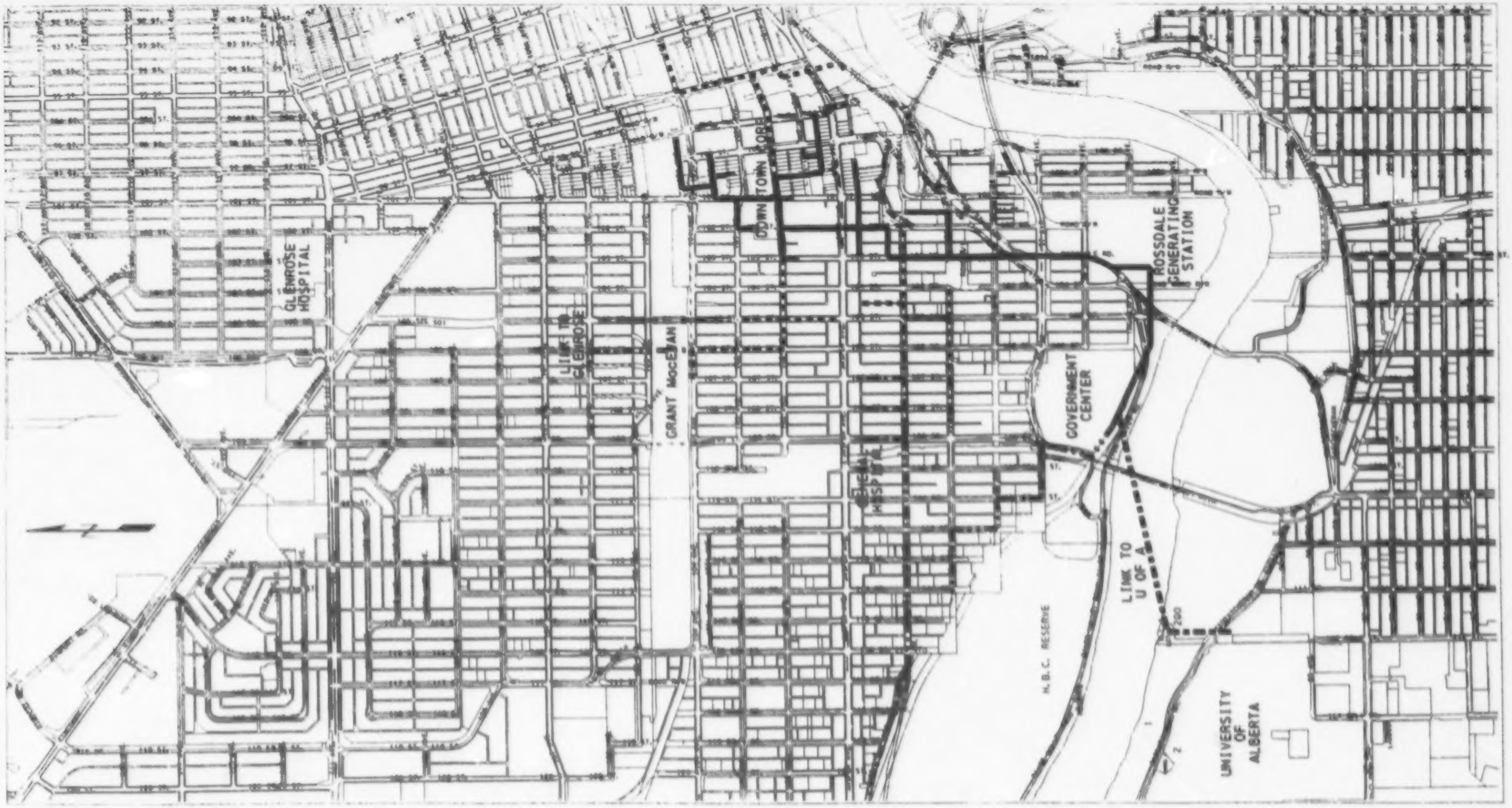
FIGURE II-1
DISTRICT ENERGY COGENERATION OF
COMBINED HEAT AND POWER


HIGH PRESSURE TURBINE
LOW PRESSURE TURBINE
HIGH PRESSURE STEAM
GEN
WASTE HEAT
CONDENSER
BUILDINGS
HEATING & COOLING PLANT
DISTRICT ENERGY
33%
67%
ELECTRICITY
WASTE HEAT
ELECTRIC ONLY POWER PLANT
ELECTRICITY
DISTRICT ENERGY
WASTE HEAT
25%
60%
15%
CO-GENERATION POWER PLANT

SOURCE: Edmonton Power.

FOLD OUT — FIGURE II - 2

FIGURE II–2
DISTRICT ENERGY DISTRIBUTION NETWORK
CASE II


GLENROSE HOSPITAL
LINK TO GLENROSE
GRANT MacEWAN
DOWN TOWN CORE
ROSSDALE GENERATING STATION
GOVERNMENT CENTER
GENERAL HOSPITAL
H.B.C. RESERVE
LINK TO U OF A
UNIVERSITY OF ALBERTA
PHASE 1 =
PHASE 2 =
PHASE 3 =
PHASE>4 =
LINE TO U OF A. =

SOURCE: Edmonton Power.

maximum station output is only needed for electricity production for relatively short periods. Peaking stations are used for capacity--stations held in reserve to meet the electrical capacity needs at the system peak demand. So long as it is not required for electrical capacity, it can make electricity and heat in a CHP mode without interrupting electricity service (see Figure II.2).

Edmonton Power is currently trying to make the district energy system economic to potential customers based on "no-cost" to the electricity consumer. In its corporate policy, EP has decided that whatever happens as a result of district energy, the electricity consumer will not see any change. Electricity prices will not go up, unless there is some direct benefit from it. This qualifier is all important as EP would like to see the direct benefits of GHG emissions reduction resulting from CIES accounted for in the electricity prices paid by customers.

The whole process of CHP from an electric utility's point of view is access to a heat sink, preferably all year round. The concept of district heating makes even more sense if cooling is added, as it gives the utility the ability to produce in the CHP mode all year round.

It is primarily the dollars saved through CHP that makes district energy more economic than individual, on-site building boilers. This is further enhanced through lower gas costs, as the CIES can negotiate a much better gas contract.

Among the many planning considerations, EP is giving particular attention two public concerns:

- under no circumstances should the CIES use CFCs; and
- CIES rate structures should encourage energy savings on both electricity and gas side.

One of EPs goals is to make Edmonton a centre of excellence for district heating and cooling technology and industry across Canada.

Heating without cooling provides only one third of the value inherent in district energy (both heating and cooling) since heating is so cheap in the buildings already. "If you are district heating based on CHP, you are really forced to have a district cooling side to give yourself a summer load. Then you can base-load your system all year."[72]

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[72] Interview with Stan Gent, Edmonton Power, May 1991.

While building owners are interested in both, their challenge is providing cooling--maintaining systems, using CFCs, and how to get CFCs after 1995. Edmonton Power is pushing a marketing concept where they are taking away building owners' incremental problems and putting them in the hands of professionals at the central district energy plant.

Down the road, fuel cells could be used at the Rossdale plant to produce heat and electricity and the district heating system would be used to distribute the heat. "If you used fuel cells in buildings in downtown Toronto, or Edmonton, then you could sterilize development of existing downtown generating plants."[73] The existing electric power stations generally have already been paid for and are close to load centers. Therefore, there is the added benefit of lower transmission losses. Repowering an existing site with fuel cells would make more sense than dispersed fuel cell use for all the same reasons that CIES is better than individual, on-site heating systems (see Part I, Chapter 3).

II.8.2 Economics

District Energy will be a wholly new, 100 percent, user-paid service offered by Edmonton Power. All marketing and economics are based on the assumption of continuous service that will grow over time.

The budget forecast for the first two years (including 1992 and 1993 engineering and marketing costs) is $90 million dollars ($1991). Edmonton Power will continue to maintain the City of Edmonton fiscal policy of a 15 percent return on equity throughout the development and growth of District Energy.

As with all energy services, a District Energy municipal franchise tax is anticipated. Therefore, a similar plan to the existing taxes for gas and electricity is proposed. Since District Energy is a value-added product, unlike gas that is a fuel, it is suggested:

- that the new tax be initially set to generate the same revenues to the City as would be lost as a result of District Energy displacing both gas and electricity;
- that the new franchise tax be phased in over time to facilitate the introduction of District Energy.

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[73] Ibid.

Rates for District Energy will be premised on two considerations:

- that over time they generate sufficient revenues to support the capital investment; and
- that they are attractive to building owners in comparison to what they pay now and into the future.

Customers may pay slightly more initially. But in the long term, building owners will realize benefits compared to what it would cost them with individual building systems. Equally important is the added value building owners will receive as a result of the many intangible benefits offered by district energy.

II.8.3 Impact Assessment

II.8.3.1 Opportunity for Infrastructure and Public Service for the Area

The location of the District Energy system in the Rossdale area makes it feasible to link the plant to:

- satellite operations at the University, Government Centre and to downtown area hospitals such as the Glenrose Centre; and
- residential District Energy services to provide the Rossdale community with heating as a demonstration of residential district heating in Edmonton. A feasibility study of this potential is underway.

The location of District Energy downtown makes other innovations in public infrastructure possible, e.g., heated sidewalks, heated bus shelters and heated road services.

II.8.3.2 Increased Economic Benefits for the City and Its Taxpayers

Edmonton Power currently contributes approximately $58 million annually to the City of Edmonton. This contribution is used to reduce taxes. The District Energy system will offer the potential to increase this contribution through a more efficient community energy production system. The benefits to the City based on an otherwise wasted resource are positive.

The continual monitoring, improvement and expansion of District Energy will mean that the development of the system will be regularly reviewed as to its efficiency and its economic contribution to the City.

II.8.3.3 Employment and Spin-off Economic Activity

Edmonton's Power's District Energy network will generate approximately 320 man-years of work during the first two years of development. The indirect spin-off from this work will add a further $100 million to the economy. This will create a very positive impact on the local business community.

II.8.4 Conclusions

Investigations into **District Energy** for Edmonton suggest that it is:

- technically feasible;
- has a strong business potential that could increase the City's revenue base;
- is acceptable to the community; and
- is an important environmental initiative.

However, District Energy's success depends on its ability to attract a sufficient customer base.

Edmonton City Council has therefore directed Edmonton Power to:

- **offer District Energy to the market-place for a minimum period of 12 months; and**
- **if the minimum penetration requirement is achieved, construct the District Energy system to provide heat in September 1994 and cooling by April 1995.**

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